This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

THE GIFT OF
Experiment Station

S
77
.E2

THIRTEENTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF MINNESOTA.

Fiscal Year July 1, 1904 to June 30, 1905.

AUSTIN, MINN.
The Basford Co., Printers.
1906.

UNIVERSITY OF MINNESOTA.

BOARD OF REGENTS.

CYRUS NORTHROP, LL. D., Minneapolis.....Ex-Officio
The President of the University.

The HON. JAMES T. WYMAN, Minneapolis.....1907
President of the Board.

The HON. JOHN A. JOHNSON, St. Peter.....Ex-Officio
The Governor of the State.

The HON. JOHN W. OLSEN, Albert Lea.....Ex-Officio
The State Superintendent of Public Instruction.

The HON. STEPHEN MAHONEY, B. A., Minneapolis....1907
The HON. O. C. STRICKLER, M. D., New Ulm.....1907
The HON. S. G. COMSTOCK, Morehead.....1909
The HON. THOMAS WILSON, St. Paul.....1909
The HON. B. F. NELSON, Minneapolis.....1909
The HON. A. E. RICE, Willmar.....1909
The HON. EUGENE W. RANDALL, Morris.....1910
The HON. DANIEL R. NOYES, St. Paul.....1910

THE AGRICULTURAL COMMITTEE.

The HON. A. E. RICE, Chairman.
The HON. JOHN A. JOHNSON.
The HON. B. F. NELSON.
The HON. S. G. COMSTOCK.
The HON E. W. RANDALL.

STATION OFFICERS.

WM. M. LIGGETT ..... Director
J. A. VYE ..... Secretary

EXPERIMENT CORPS.

SAMUEL B. GREEN, B. S.,.....Horticulturist
HARRY SNYDER, B. S.,.....Chemist
T. L. HAECKER.....Dairy Husbandry
M. H. REYNOLDS, M. D., V. M.,.....Veterinarian
ANDREW BOSS.....Agriculturist and Animal Husbandry
FREDERICK L. WASHBURN, M. A.,.....Entomologist
1. A. HOVERSTAD, B. Agr.,.....Superintendent, Crookston
A. J. McGUIRE, B. Agr.,.....Superintendent, Grand Rapids
J. A. HUMMEL, B. Agr.,.....Assistant Chemist
COATES P. BULL, B. Agr.,.....Assistant in Agriculture
A. G .RUGGLES, M. A.,.....Assistant Entomologist
D. A. GAUMNITZ, B. Agr.,...Assistant in Animal Husbandry
A. D. WILSON, B. S. Agr.,.....Assistant in Agriculture
E. C. PARKER, B. S. Agr.,.....Assistant in Agriculture

The bulletins of this Station are mailed free to all residents of this State who make application for them.

Minneapolis, Minn., July 1, 1905.

To His Excellency, John A. Johnson,

Governor of Minnesota:

I have the honor to transmit to you herewith the annual report of the Agricultural Experiment Station of the University of Minnesota for the fiscal year ending June 30, 1905.

JAMES T. WYMAN,

President Board of Regents.

154192

LIST OF BULLETINS PUBLISHED DURING THE FISCAL YEAR, ENDING JUNE 30, 1905.

	Pages.
Press Bulletin No. 21, Seed Wheat Famine.....	
Press Bulletin No. 22, Insects and Insect-like Animals attacking Live Stock in Minnesota.....	
Press Bulletin No. 23, Dipping Live Stock.....	
Press Bulletin No. 24, Seed Grain.....	
Bulletin 87—Horticultural Division—Potatoes at University Farm	1-12
Bulletin 88—Entomological Division—Injurious Insects in 1904	13-190
Bulletin 89—Division of Agricultural Chemistry—Soil Investigations	191-212
Bulletin 90—Division of Agricultural Chemistry—1. Heavy and Light Weight Grains. 2. Starchy and Glutenous Grains. 3. Light and Dark Colored Flax Seed. 4. Rusted Wheat. 5. Milling Tests of Wheat	213-238
Bulletin 91—Northwest Experiment Farm, Crookston, Minn.—Poultry Culture in Minnesota.....	239-258
Bulletin 92—Division of Agricultural Chemistry—The Digestibility and Nutritive Value of Cottage Cheese, Rice, Peas and Bacon	259-275

REPORT OF THE DIRECTOR OF THE EXPERIMENT STATION.

To the President of the Board of Regents:

I have the honor to transmit herewith the thirteenth annual report of the Agricultural Experiment Station of the University of Minnesota, covering the work done at the Station at St. Anthony Park, and the two sub-stations established by an act of the legislature in 1895, the one at Crookston and the other at Grand Rapids, Minnesota.

The report includes Bulletins 87 to 92 inclusive, published during the fiscal year, and a full account of the expenditure of the annual appropriation from the United States Government, as well as that received from the current expense fund of the University.

The Minnesota Agricultural Experiment Station, in account with the United States Appropriation, 1904-1905.

Dr.

To receipts from the treasurer of the United States, as per appropriation for fiscal year ending June 30, 1905, as per act of congress approved March 2, 1887		$15,000.00

Cr.

By salaries	$10,129.03	
By labor	2,284.62	
By publications	75.28	
By postage and stationery	317.21	
By freight and express	27.63	
By heat, light, water, and power	777.35	
By chemical supplies		
By seeds, plants and sundry supplies	254.91	
By fertilizers	40.00	
By feeding stuffs	703.78	
By library		
By tools, implements, and machinery	54.25	
By furniture and fixtures	5.75	
By scientific apparatus		
By live stock	185.00	
By traveling expenses	12.15	
By contingent expenses		
By buildings and repairs	133.04	
Balance	$15,000.00	$15,000.00

VI

FINANCIAL STATEMENT.

Statement of disbursements and receipts of the Minnesota Experiment Station for the twelve months beginning July 1st, 1904, and ending June 30, 1905, inclusive:

	Disbursements.	Receipts.	Cash Outlay.
Station	$16,441.89	$651.25	$15,790.64
Agriculture	11,274.78	1,482.26	9,792.52
Horticulture	4,511.83	713.73	3,798.10
Chemistry	3,153.51	16.57	3,136.94
Entomology	1,205.30	.....	1,205.30
Veterinary	2,160.41	156.90	2,003.51
Dairy	1,200.00	.....	1,200.00
Animal Husbandry	9,990.04	3,167.15	6,822.89
	$49,937.76	$6,187.86	$43,749.90
Crookston	$6,900.87	$900.87	$6,000.00
Grand Rapids	5,049.77	1,049.77	4,000.00
	$11,950.64	$1,950.64	$10,000.00

DIVISION OF AGRICULTURE.

The work for the year in the Division of Agriculture has been a continuation of tests of varieties of grain which have been a prominent feature of the work since 1890; methods of cultivation have been studied and a great deal of work has been done in rotation of crops; the work with tame grasses and alfalfa has been especially encouraging. The experience of recent years goes to show that it requires only proper tillage and preparation of land, combined with the selection of good seed, to insure growing alfalfa in most parts of Minnesota.

The plant breeding work carried on in co-operation with the United States Department of Agriculture is on a sound basis and results are rapidly being obtained. We now have in the field tests, several promising varieties of grain that have been originated through cross breeding or straight selections from the crop nursery.

The bulletin on farm statistics which was mentioned in the report of a year ago as being ready for publication was held to get further data on subjects where averages were desirable. It was thought advisable to retard publication a year rather than to publish results which were not absolutely reliable. The farm management bulletin has been held for similar reasons though both are now practically ready for publication. Material has been gathered also for a bulletin on Bromus Inermis and will be published as soon as is deemed advisable.

During the fall of 1904 the Division made quite a comprehensive exhibit of methods of field crop breeding at the St. Louis Exposition. This work was, likewise, in co-operation with the United States Department of Agriculture and resulted in a wide dissemination of knowledge of the methods employed in Minnesota for developing new varieties of grain. It is a matter of pride to the division that one of the new varieties of wheat developed in the crop nursery (Minnesota No. 169) was given a grand championship prize at this exposition.

A reorganization of this division was made necessary in January, 1905, by the appointment of Prof W. M. Hays to the position of Assistant Secretary of Agriculture. His associate, Prof. A. Boss, has been placed in charge of the work and Mr. A. D. Wilson and Mr. E. C. Parker have been made assistants in Agriculture.

REPORT OF THE DIVISION OF HORTICULTURE.

The work in the division of Horticulture and Forestry for the past year has included the following lines of experimentation, which are largely a continuation of work which has occupied our attention for a number of years past.

The work of originating hardy varieties of apple is still carried on, both at this station and at Owatonna, the object being to find varieties that are better fitted to our conditions than those we now have. Our seedling orchard has been increased by the addition of several hundred permanently set seedling trees, and about 10,000 seedlings have been raised from seed of our hardiest kinds. Some of the seedlings that have fruited for the first time in our seedling orchard are of good size and quality, and are of much promise. The seedling apples competing for the prize of $1,000 offered by the Minnesota Horticultural Society, are on trial in our orchard. The result of this work being carried on here is to bring together perhaps the best collection of hardy seedlings to be found in America.

The work of improving our hardy plums has occupied much of our attention and 400 plum seedlings have been set out in orchard rows for fruiting. Most of these are seedlings of the Surprise, which we regard as of much promise. We are also growing several hundred seedling strawberries, obtained from seed of the best kinds. In addition to the above lines of seeding work we are testing a large number of varieties of the various fruits.

In the case of vegetables our attention has been confined largely to experiments with potatoes for the purpose of determining the best way of overcoming the great injuries from rot and blight which have so lessened our potato crop during recent years. This has followed two lines: One is the trial of new varieties of potatoes and the other is the raising of seedling varieties of potatoes, the object in both cases being to get varieties that are immune to potato diseases.

Experiments have also been made in the spraying of potatoes to determine the best way of protecting them from disease. The data in regard to our experiments with potatoes were published in bulletin No. 87, which is made a part of this report.

In the line of forestry and ornamental planting, we have raised a large number of seedlings of hardy plants that seemed especially desirable for introduction into this section. These in due time will be distributed by the nurserymen of this section.

IX

DIVISION OF CHEMISTRY.

The division of Agricultural Chemistry has issued three bulletins during the year: No. 89, soil investigations, treating of the influence of crop rotations and farme manures upon the humus content and fertility of soils; the water soluble plant food of soils, and the production of humus in soils; No. 90, Wheat and Flour investigations, giving the differences in composition between light and heavy weight grains, the detection of starchy and glutinous kernels, the characterists of rusted wheat and milling and baking tests; No. 92, treating of the digestibility and nutritive vale of cottage cheese, rice, peas and bacon. Professor Snyder has also published through the Chemical Publishing Co., Easton, Pa., his revised work on soils and fertilizers which has been adopted as a text in a number of agricultural colleges and schools. In co-operation with the office of experiment stations of the United States Department of Agriculture a bulletin on the nutritive value of bread has also been issued, and also an article in the Year Book of the department on the same subject. The work of the division of agricultural chemistry is largely centered on soil investigations, human foods and wheat and cereal problems. The division makes a large number of free analyses for the farmers of the state of materials used in agricultural practice.

DAIRY DIVISION.

The work in this division has been continued along the plan outlined in the last report. The complete and careful records that have been kept since the organization of the division in feed consumed and dairy products yielded by each member of the dairy herd furnishes valuable data on cost of milk production, the rearing of young stock and the determination of the nutrients required in economical milk production and the growing of dairy animals. From its inception there has been constantly kept in view the needs of data for both popular and scientific information, the former dealing more especially with the herd as a business proposition, while the latter has to do with the methods of breeding, rearing and feeding for large productive powers and economy of production. The progress made in this work has far exceeded expectations.

Since the publication of bulletin 79, treating on the Food of Maintenance, Nutritent Requirements in Milk Production, two winters' work have been added and publication of the results postponed by suggestion of most eminent authorities, with a view of accumulating more data The advanced

and improved method in which this subject was presented in bulletin 79 has been adopted by some of the other experiment stations with very satisfactory results. The basic principle, that a feeding standard for milch cows must be adjusted to quantity and quality of milk yielded is now generally recognized, and the one tentatively formulated in bulletin 79 will ultimately form the basis for one that will be both practical and scientific.

The experiments that are being conducted in this division are beginning to show that experiments as ordinarily conducted are of too short duration; that the residual effect of feeding will have a bearing upon milk production for one or more years; that it requires several years of systematic feeding along one line to secure definite results. They are also bringing to light the fact that the feed stuffs grown upon our western fertile farms come nearer providing the constituents actually needed in milk production than had been generally supposed; that the amount of protein prescribed in the feeding standards heretofore in general use is in excess of the amount actually needed and that a marked saving may be made in preparing feed for dairy cows.

VETERINARY DIVISION.

There has been the usual run of correspondence and office work during the past year, but with a constant tendency to reduce the amount of general hospital clinic and utilizing this time and the stable room for station work.

An important work in stable ventilation was taken up during this period, the endeavor being first to secure a physiological basis for defining and estimating the effect upon confined animals of naturally contaminated stable air, and second, to determine the least amount of ventilation compatable with health, and the most economic feeding of confined stock, and finally to be worked out later, to compare the relative efficiency of different systems and methods of stable ventilation. Our work during this period has been continued in two series and we have made studies of the blood and urine in various details from animals in free air and in confined stable air. The periods of confinement have varied from six to 42 hours during the work reported here; careful records have been kept of stall conditions, weights of confined animals, etc. A very large amount of material has already been tabulated and we now have on hand sufficient matter for two and perhaps three bulletins, which will be issued as soon as results can be verified and the manuscript gotten ready.

A considerable amount of work has also been done with the blood and urine of milk fever patients. This latter work can only be done as opportunity offers, and the cases within reach have not been so numerous as during past years.

DIVISION OF ANIMAL HUSBANDRY.

In 1902 definite plans were formed in the Division of Animal Husbandry for studying the cost of production of meat producing animals. Methods were formulated which would give data in regard to the cost of growth and nutrients required by the different classes of animals. Work has been continued along this line, during three years and many facts have been accumulated that make possible a compilation of valuable information in animal production. Up to the present time very little has been placed in shape for publication, it being considered advisable to duplicate and triplicate any experments before publishing results. Some features of the work are finished and results will soon be published.

The herds and flocks have been kept at about the normal number, the effort being to build up in quality rather than in quantity. The number of animals on hand at the close of the year is perhaps a little less than a year ago on account of selling a number of steers that were finished for market. The funds accruing from the sales were turned in to the University and the money was not available to repurchase until August, 1905. Records of feed required and gains made have been kept with all classes of animals and the cost of growing sheep and swine on different kinds of forage, and on forage in connection with grain foods, has been given a great deal of attention. This work will be duplicated during the ensuing year and extended with a view to publishing a bulletin on forage and pasture crops.

During the year only one bulletin—Press Bulletin No. 23, on Dipping Live Stock has been published by the division.

Mr. D. A. Gaumnitz has been made assistant in the Division of Animal Husbandry, and the work is well organized for definite results in the future.

DIVISION OF ENTOMOLOGY.

Experiments have been conducted against the leaf hopper in nurseries, and the cabbage maggot, the latter insect being a serious pest in our market gardens. The nurserymen have been notified of the appearance of the imported willow and alder insect, known as the European Willow and Alder Borer.

Eleven lectures were delivered to farmers in various places throughout the state, and in almost every case the lecture was illustrated with lantern views. A large number of letters were written in answer to inquiries regarding insect pests, and communications sent to the papers of the state regarding especially injurious insects. Bulletin 88 was issued in December, 1904, which contained a key to insects affecting small fruits, with remedies for these insects. The same bulletin also contained directions for combating the insects of the vegetable garden, and some of the common insects of the flower garden.

The entomologist was allowed about a quarter of an acre on the Experiment Station grounds for experiemental purposes along the line of entomology, and found it very useful. It was planted with nursery trees and small fruits, and experiments against the cabbage maggot, and also with honey plants were carried on.

The Cottony Maple Scale has been extremely abundant and destructive in the Twin Cities and various towns of the state and neighboring states, and definite directions have been given citizens for the control of this pest.

In October, 1904, a leaflet was issued, containing an account of some special experiments performed against the flour moth, which leaflet was sent to the millers in Minnesota.

In April, 1905, Press Bulletin, No. 22, was issued, entitled "Insects and Insect-like Animals Attacking Live Stock in Minnesota." In this bulletin were discussed the external and internal parasites of horses, cattle, sheep, hogs, dogs, cats and poultry.

Work against the cabbage maggot has been continued in co-operation with a number of market gardeners.

POULTRY DIVISION.

The work in this division has been confined to a study of the best conditions for farm flocks. The problem of ventilation of poultry houses in winter has been studied and an experiment with cloth frames in place of half the windows on the south side of the house has proved very satisfactory as a means of ventilating and keeping the air of the house dry. Trials with incubators and brooders and experiments with different methods of preserving eggs for winter use have been continued. The feeding and management of fowls for winter egg production has received special attention.

This division is in great need of material to replace the old fences which are so badly rusted as to be useless. More house room for laying hens and material with which to build colony houses for the young fowls are also urgently needed.

NORTHWEST EXPERIMENT FARM.

The work with poultry has been very successful. The farm now has White Wyandottes, White Leghorns and Barred Plymouth Rock, from which eggs have been distributed to many farmers throughout the Red River Valley. Bulletin No. 91 on Poultry culture was issued during the year and the 15,000 edition is now entirely exhausted. Considerable work has been done in preparation for a complete system of drainage which is hoped may be put in operation the coming year. Some pure bred cattle from among the Herefords. Galloways, and Shorthorns have been purchased as foundation stock from which to build up a herd.

THE NORTHEAST EXPERIMENT FARM.

During the past year the field experiment work has been practically the same as the three years previous—testing of different varieties of plants and crops for this section of the state, crop rotation, and different methods of tillage.

In the variety tests there were grown 25 different varieties of wheat, 32 of oats, 22 of barley, 11 of corn, and 51 of potatoes. The years' work will about conclude this experiment of testing varieties, it having been conducted for five years. The varieties found best adapted to this northern section will be retained for continued use and improvement.

An apple orchard of 150 trees has been set out and also considerable small fruit, including the highbush cranberry.

Dairying, stock raising, and poultry are being given particular attention. Dairying is being made a special feature and in connection with it the production of bacon pork. The profit from this combination for this section of the state is very promising. A silo of 100 tons capacity has been built and a farm creamery is now under construction. The work of the experiment farm and results obtained during the past year have been published in press bulletin form and circulated thru the local papers of northeastern Minnesota.

Reprint of Bulletin No. 87.

POTATOES AT UNIVERSITY FARM.

SAMUEL B. GREEN, ASSISTED BY HAROLD CUZNER.

The growing of potatoes in Minnesota is an important industry. Our annual production is from 16,000,000 to 20,000,000 bushels, from one-third to one-half of which are annually exported. The potatoes raised in Minnesota are of exceptionally good quality and are generally sought after in the potato-consuming markets of the United States. Not only are they bought for table use, but the business of shipping potatoes to Missouri, Kansas and other southern points for seed, is an important and growing one.

When potatoes are less than twenty cents a bushel a large quantity of them are made into starch, which industry is of great assistance in maintaining the price of potatoes in this secton.

It has been the practice of the Minnesota Experiment Station to grow about fifty varieties of potatoes each year. During the past few years the potato crop in this section has been seriously injured by rot and blight, and in considering the results of the trials of varieties at the station, special attention has been given to noting the power of resistance of each kind to disease. The method followed in growing potatoes used in the experiments here noted, has been to plant sixteen inches apart, in rows thirty inches apart, and to cover four inches deep. The seed has been cut to two or three eyes to a set, using a rather large piece of seed, such as would contain as much in bulk as a rather small egg. One or more rows was planted to each variety, and each row was eight rods long. The following table (TableI.) shows the yield, calculated to bushels per acre, of marketable, small and rotten potatoes for each veriety.

By potato rot is here meant both the wet and dry rot of potatoes as they are commonly recognized by potato growers in this section. These diseases are especially troublesome on wet or heavy soils, and in moist, cool weather.

By blight is here meant the diseases that cause dying of the tops of potatoes before the tubers are mature. This is very troublesome in some seasons and often cause much serious

loss to potato growers. These troubles generally occur together, but we sometimes have serious injury from blight without having the rot.

TABLE NO. 1.—Potato Yields Calculated to Bushels per Acre of Large, Small, Marketable and Rotten.

VARIETY	No of Rows	Yield per Acre in Bushels				Per Cent. Rotten
		Large	Small	Rotten	Total	
Banner	4	154	8	50	292	20.5
Bartlett	1	143 2-3	17	10	170 2-3	5.8
Bovee	1	78 1-2	19	26	123 1-2	21.1
Burbank	4	204 1-3	10 1-2	66	280 5-6	23.5
Clay Rose	2	223	21 1-3	.....	244 1-3	1.0
Clinton	4	29 1-3	6	24	59 1-3	42.3
Columbian	2	20	12 1-2	10	42 1-2	23.8
Commercial	1-2	25	5	20	50	40.0
Considerable Seed	2	85	10 1-2	40	135 1-2	29.6
Early Andes	2	79 1-4	18 1-2	25	142 3-4	10.5
Early Harvest	3	107	26 1-2	26	159 1-2	16.3
Early Market	1	57 1-2	15	25	97 1-2	25.7
Early Michigan	2	230	24	50	304	13.1
Extra Early Pioneer	2	67 2-3	9 2-3	26	102 1-3	22.5
Hullet's Rust Proof	1	105 1-3	9 1-2	10	124 5-6	8.0
Irish Cobbler	3	121	14	30	165	12.1
Lincoln	5	117	13 2-3	38	168 2-3	22.6
Main Crop No. 2	2	56	21	15	92	16.4
Medium	5	153 1-3	8	6	167 1-3	3.5
New Wonderful	3	108	4	30	142	21.1
Ohio Junior	2	59 1-2	10 1-2	38	108	35.1
Pat's Choice	1-2	57 1-2	4	25	86 1-2	29.0
President McKinley	1	115	28	38	181	20.9
Pure Gold	1	115	17 1-4	30	162 1-4	18.5
Peach Blow	2	41 1-2	11 1-2	9	61 1-2	14.7
Sir Walter Raleigh	2	249 1-3	7	3	259 1-4	1.1
Up-to-Date	3	45	9	20	74	27.0
Vigorosa	2	75 1-3	42	32	149 1-3	21.4
Vornehm	2	51	12	12	75	16.0
White Beauty	4	221	60	10	291	3.4
White Mammoth	4	137	4	20	161	12.4
Number 26	2	67	12	17	96	17.7
Number 32	2	45	12	22	89	22.2
Number 33	2	45	24	15	84	17.8
Number 34	2	88	6	23	117	10.2
Number 37	2	111	17	8	136	5.8
Number 38	2	67 1-2	18	6	91 1-2	6.5
Number 39	2	72 1-2	20	7	99 1-2	7.0
Number 40	1 1-2	73	38	35	146	23.9
Number 41	2	63 1-4	49	15	87 1-4	17.2
Number 42	1-2	40	15	24	79	30.3
Number 43	2	64 1-3	44	16	124 1-3	12.9
Number 44	2	94 1-2	60	18	172 1-2	10.4
Number 45	2	72 2-3	30	24	126 2-3	19.0
Number 46	2	63 2-3	32	20 1-3	116	17.2
Number 47	2	44 1-3	31	10	85 1-3	11.4
Number 48	2	59 1-4	28 1-2	4	91 3-4	4.4
Number 49	2	62	5	.....	67	.....
Number 50	3	103 1-3	37 1-3	18	158 2-3	11.3

DESCRIPTION OF VARIETIES OF POTATOES.

Banner.—Medium to large; oblong, somewhat flattened, tapering toward stem end; skin, white and smooth; eyes, few and shallow; early, good crop; good market variety.

Bartlett.—Small, round; skin, greenish white; eyes, medium to large and deep; productive, good.

Bovee.—Medium, kidney; skin white, rough, with pink markings; eyes medium size and deep; early; prolific and profitable variety; good cooking qualities.

Burbank.—Large, kidney; russet skin, white netted; eyes, few and shallow; late; standard of form and quality for this market.

Clay Rose.—Medium, long oblong; skin rose colored, somewhat netted; large, often deep, variable eyes.

Clinton.—Medium, slightly oblong; skin white, smooth; eyes shallow; productive, vigorous grower.

Columbian.—Medium, oblong, tapering toward stem end; skin light green; eyes medium in size and depth.

Commercial.—Medium to large; irregular; flattened; skin light pink, nearly white; surface irregular, rough; eyes small and shallow; prolific variety; considerable waste in paring; rotted badly in field and more in cellar.

Early Andes.—Medium, oblong to oval; slightly flattened; skin pink, smooth, eyes numerous and shallow; early, good cooking qualities.

Early Harvest.—Medium, oblong, slightly flattened; skin, white and smooth; eyes quite large, medium depth; early, strong grower; good cooking qualities.

Early Market.—Medium, nearly round; skin white, smooth; eyes small, rather long; early.

Early Michigan.—Medium to large; flattened oval to oblong; skin smooth, white and somewhat russeted; eyes small, shallow; good quality; tubers not even in size.

Extra Early Pioneer.—Medium, oblong; skin, white, smooth; tinged with pink; eyes rather shallow and broad; early; average yield for early potato.

Hullet's Rust Proof.—Medium, round to kidney shape; skin white, finely netted; eyes shallow, small.

Irish Cobbler.—Large, short oblong, somewhat flattened; skin white; eyes medium deep; very productive; good cooking qualities, very white and mealy.

Lincoln.—Medium to large, oblong flattened; skin white, smooth, with faint pink patches; eyes deep and sharp; early crop.

Main Crop No. 2.—Medium, oblong; skin white, tinged with pink, smooth eyes, deep, sharp.

Medium.—Medium, oblong; skin white, slightly netted; eyes small and shallow.

New Wonderful.—Medium to large; oblong, tapering toward the stem end; skin white, heavy netted; eyes small, shallow.

Ohio Junior.—Medium, oblong to kidney; skin white, tinged with pink; eyes numerous, medium in depth; early crop.

Pat's Choice.—Medium to large; oblong, tapering; skin pink, smooth; eyes few, small, shallow, decidedly pink; good bearer; good cooking qualities; early.

President McKinley.—Medium; kidney shaped; skin white smooth; eyes, deep; early productive.

Pure Gold.—Medium, oblong; skin white, slightly netted; eyes few, shallow; average early crop.

Peach Blow.—Medium, round; skin, smooth, white, tinged with pink.

Red River White Ohio.—Medium; long, flattened; skin white; good extra early crop; vigorous grower; eyes large, shallow.

Rural New Yorker.—Medium to large; oval, flattened; skin smooth, white; eyes few, large and shallow; late crop; productive.

Sir Walter Raleigh.—Medium to large; round; skin white, with patches of russet; eyes deep; late crop; good market variety; productive.

Up-to-Date.—Medium, round; skin white, smooth; eyes shallow; late crop.

Vigorosa.—Medium to large; oval, flattened, quite uniform; skin pinkish white, smooth; large shallow eyes; strong vigorous grower; good yielder; fairly good keeper.

Vornehm.—Medium; oblong; skin white, netted; very shallow eyes; good crop; early; very fine cooking qualities.

White Beauty.—Medium to large; long, nearly cylindrical; slightly flattened; skin smooth, white russeted; eyes small, shallow, inconspicuous; good yielder; one of the best keepers.

White Mammoth.—Medium to large; short, thick, flattened; uniform in size; skin white, well netted; eyes small, medium depth; good yielder; reliable market sort; excellent quality.

BORDEAUX MIXTURE FOR PREVENTING POTATO BLIGHT AND ROT.

In the treatment of potatoes with Bordeaux mixture for the prevention of blight, this station was one of the first to get results. In some experiments made in 1889 the vines that were treated with Bordeaux produced 50 per cent more potatoes than those that were not treated, and the tops of the treated plants remained green for perhaps two weeks after those not treated had died down. For a number of years after this we failed to get satisfactory results; trials with it were given up, for while there would often be some increase from the application of Bordeaux mixture, yet the increase was so little that we had come to the opinion that it would not pay to do it. Last year, however, we lost perhaps 50 per cent of our potatoes from rot, and our vines were more or less injured by the blight. In the spring of 1904 we outlined some experiments to test again the value of Bordeaux mixture as a preventative of potato diseases. In these experiments we have aimed to determine the number of applications of wet and dry Bordeaux mixture that would be most effective in preventing disease, and the comparative merits of wet as compared with dry Bordeaux mixture. For description of each of these mixtures see page 4. In Table II. is shown the number of rows in each plot, the yields of large small and rotten potatoes and per cent of rotten potatoes from each plot. Table III. shows the comparative merits of wet as compared with dry Bordeaux mixture and the check plots.

FORMULA FOR WET BORDEAUX MIXTURE.

Dissolve five pounds of blue vitriol (sulphate of copper) in ten gallons of water in a wooden or earthenware vessel. As this substance dissolves very slowly in cold water, and solutions of it are very heavy, it is well to suspend it near the top of the water. (It dissolves more quickly in hot water.) In another vessel slack five pounds of good fresh quicklime in ten gallons of water. When the mixture is wanted, pour the blue vitriol and lime slowly (at the same time) into a barrel containing thirty gallons of water, stirring all the time. When thoroughly stirred the mixture should be of a clear, sky blue color. After being mixed for a day or two the mixture loses much of its strength so it is well to use only that which has been mixed for a short time.

FORMULA FOR DRY BORDEAUX MIXTURE.

Dissolve four pounds of blue vitriol (sulphate of copper) in two and one-half gallons of water. Slack four pounds of lime slowly in two and one-half gallons of water, so as to give a fine powder, and as a result, milk of lime. In a large shallow box place sixty pounds of air slack lime. In another mix thoroughly the copper solution and the milk of lime. Empty this material into the sixty pounds of air slacked lime and thoroughly mix with a hoe. While still damp this material must be rubbed through a comparatively coarse sieve. It should then be spread out and allowed to dry well and then passed through a 100-mesh sieve.

TABLE NO. 2.—Showing the Results from the Treatment of Potatoe Vines with Bordeaux Mixture.

N indicates check plat without treatment.
D indicates that treatment was with dry Bordeaux mixture.
W indicates that treatment was with wet Bordeaux mixture.

VARIETY.	No. of Rows	Kind of Bordeaux Mixture Used	No. of Times Sprayed	YIELD PER ACRE*				Per Cent Rotten
				Large	Small	Rotten	Total	
Early Michigan ...	2	N	0	124	26	62	212	29.2
	2	D	3	115	26	58	199	29.1
	2	D	6	149	11 1-2	75	235 1-2	31.9
	2	D	2	117	21 1-4	56	194 1-4	28.8
Red River White Ohio	2	N	0	60	39 1-2	32	131 1-2	24.4
	2	D	3	108 1-4	7 3-4	49	165	29.8
	2	D	6	134 1-3	20 1-4	60	214 7-12	28.0
	2	D	2	84	19	46	139	33.0
Sir Walter Raleigh.	3	D	3	134 1-4	5	43	182 1-4	23.5
	3	D	6	162 3-4	7 1-2	35	205 1-4	17.0
	3	D	2	152 1-2	4 1-2	35	192	18.2
	7	N	0	106	3 1-3	13	125 1-3	17.6
	3	W	3	197 1-3	4 1-4	43	244 7-12	11.5
	3	W	6	212 3-4	3 3-4	30 1-3	252 5-6	22.9
	3	W	2	162	6 1-3	50	218 1-3	10.4
Rural New Yorker.	3	D	3	163 1-3	6	43 2-3	213	20.1
	4	D	6	172 2-3	5	30	207 2-3	14.4
	3	D	2	191	6	37 1-3	234 1-3	15.9
	5	N	0	193	10 2-3	33 2-3	237 1-3	13.6
	3	W	3	244	8	53	305	17.3
	4	W	6	231	5	43 1-2	279 1-2	15.3
	3	W	2	227	8	45 1-2	280 1-2	16.0
	5	N	0	189 1-3	8 1-3	51 2-3	249 1-3	20.8
	3	D	3	193 2-3	10	59	262 2-3	20.9
	4	D	6	179	10 1-2	53	242 1-2	21.9
	3	D	2	203	10 2-3	52	255 2-3	20.3
	5	N	0	186	10	54 1-3	240 1-3	22.5
	3	W	3	276 1-3	9	60	345 2-3	17.3
	4	W	6	472	12 1-2	59 1-3	543 5-6	10.8
	3	W	2	259 2-3	4	59 1-2	323	18.2
	2	N	0	160 1-3	6 2-3	52	219	23.5

* In bushels.

TABLE NO. 3.—Shows the Comparative Results from the Use of Dry Bordeaux as Compared with Wet Bordeaux Mixture.*

By Check is meant the plat that was untreated.

VARIETY	Wet	Dry	Check	Gain of Wet over Dry	Gain of Wet over Check	Gain of Dry over Check	No. of Times Sprayed
Sir Walter Raleigh:							
Large	197	143	106	54	91	37	3
Small	4 1-2	5	3 1-2				
Rotten	43	43	13	37.7%	85.8%	34.9%	
Large	212	162 3-4	106	49 1-4	106	56 3-4	6
Small	3 3-4	7 1-2	3 1-2				
Rotten	30 1-4	35	13	30.2%	100%	52.8%	
Large	162	152 1-2	106	9 1-2	56	46 1-2	2
Small	6 1-3	4 1-2	3 1-2				
Rotten	50	35	13	5.9%	52.8%	43.3%	
Rural New Yorker:							
Large	275 1-3	178 1-2	192 1-3	96 5-6	83		3
Small	8 1-2	8	8 1-2				
Rotten	56 1-2	51	47 1-3	53.9%	43.6%		
Large	301 1-2	175 1-2	192 1-3	126	109 1-6		6
Small	8 3-4	7 1-2	8 1-2				
Rotten	46 1-2	45 1-6	47 1-3	71.4%	56.7%		
Large	243	197	192 1-3	46	50 2-3	4 2-3	2
Small	6	8 1-3	8 1-2				
Rotten	52 1-2	44 1-2	47 1-3	23.3%	26%		

Results stated in Bushels and per cent.

Wet Bordeaux mixture was applied with a spray pump. Dry Bordeaux mixture was applied with a dusting machine. The number of times these mixtures were applied to each plot is stated in the table.

SCAB OF POTATOES.

A report was made in a former bulletin on the efficiency of the treatment for potato scab, so that it is not necessary to include it here, but a brief notice of this disease and methods of preventing it is given in the following pages, taken from "Vegetable Gardening," by the author.

Scab of potatoes is caused by a fungous plant working in the surface of the potato. The germs of it are very abundant and live for many years in the soil and also over winter

on the potatoes. If these germs are fed to stock they undoubtedly grow in the manure, and the use of such manure may often be the cause of infection. Also they may be spread in the soil by natural drainage and land receiving the drainage from infested fields may become infected with the disease without ever having had potatoes on it. Scabby seed potatoes when planted on new or old potato land will generally produce a scabby crop, but the amount of the disease will generally be much more on the old land than on the new.

Perfectly clean seed potatoes planted on land which is free from the scab fungus will always and in any season produce a crop of smooth, clean potatoes, no matter what may be the character of the soil; but apparently clean seed potatoes may have the germs of the scab fungus on their surface. This is often the case where they have been sorted out from a lot that is somewhat infected with scab. In this latter case, the tubers should at least be thoroughly washed in running water, to remove any germs that may be present, or, what is better yet, be treated with corrosive sublimate (mercuric bichloride) as recommended below.

Land infected by the germs of potato scab will produce a more or less scabby crop, no matter how clean and smooth the seed used.

Scabby potatoes should be dug as soon as mature, since the scab fungus continues to grow on the potatoes as long as they are in the ground.

Scabby potatoes may be safely used for seed provided they are first treated in such away as to destroy the germs of the scab that adhere to them. There are many methods of doing this, but the most practical now used are as follows:

Corrosive Sublimate Treatment.—Procure from a druggist two ounces of powdered corrosive sublimate (mercuric bichloride); put this into two gallons of hot water in a wooden or earthenware vessel and allow it to stand until dissolved. Place thirteen gallons of water in a clean barrel, pour in the solution of corrosive sublimate and allow it to stand two or three hours, with frequent stirring, in order to have the solution uniform. Select potatoes as nearly free from scab as can be obtained; put the seed potatoes into bags, either before or after cutting them, and then dip them into the corrosive sublimate solution and allow them to stay in for an hour and a half. If seed potatoes are treated in this way and then planted on land free from scab, the resultant crop will seldom be seriously injured by scab. The expense of this treatment,

including labor, should not exceed one dollar per acre, as the material may be used repeatedly. But the treated potatoes should never be fed to animals, as corrosive sublimate is a deadly poison.

Formaline Treatment.—This material should be mixed with water at the rate of eight ounces (one-half pint) of commercial formaline to fifteen gallons of water. The potatoes should be soaked two hours in it. If this method is used the seed should be planted within two or three days after treatment. This material gives equally as good results as corrosive sublimate. It is slightly more expensive, but the expense is light in any case. It has, however, great advantages over the latter in that it is not so dangerous, and being a liquid is easily diluted for use and may be placed in any kind of a receptacle. This material does not in any way injure the tubers or make them dangerously poisonous. One pound of formaline, costing not more than fifty cents, will make thirty gallons of the disinfecting solution, and is enough to treat fifty bushels of potatoes. If the solution stands a long time it will probably lose strength.

Exposing to Light.—If the tubers are exposed to the full sunlight for several weeks before planting the scab germs will be largely destroyed. It would be a good plan to turn such potatoes occasionally in order to expose them fully to the light

As a result of following out this method of preventing scab on potatoes at the Experiment Station for more than five years, we have grown potato crops each year that have been nearly free from this disease, and we believe that the farmers of Minnesota cannot afford to neglect this simple and inexpensive method of treatment.

SEEDLING POTATOES.

At the Minnesota Experiment Station we have grown perhaps 2,000 or more seedling potatoes, but thus far have failed to get a kind that is a sufficient improvement over what we now have to warrant its introduction, with the exception possibly of the two or three seedlings mentioned below.

The potato plants of this section seldom produce seed, but occasionally we have a variety that is very productive of seed, such for instance as our No. 2, which seems inclined to produce a large amount, and from this we have raised many seedlings. The best lot of seedlings that we have ever raised were from seed that came to us from J. M. Reed of Wisconsin. In

our experience, potatoes from seed have seldom attained their full size until the second season from the time the seed was sown, but I am inclined to think that unless the potatoes are of fairly good edible size the first year, it is not worth while to keep them longer. In this connection it might be interesting to note that Mr. Luther Burbank, who originated the well-known Burbank potato, and many other valuable plants, told me a few years ago that that potato was of full size the first year.

Of the seedlings we now have on hand those that are most promising are Nos. 37, 40 and 44, which are varieties of good form and productive, and we shall probably send them out for trial in various portions of the state within a few years.

In raising seedling potatoes, we have found it best to separate the seed from the pulp in the same manner as the seed of tomatoes is commonly saved; sow it about the first of April and pick out the small plants into boxes or thumb pots, from which they should be transplanted to the open ground as soon as the weather is settled. The seed grows very readily and it is an easy matter to get more seedlings than one can manage to advantage.

RESULTS.

1. In considering varieties of potatoes as regards their resistance to rot, it should be noted that potatoes of the type of Sir Walter Raleigh and Rural New Yorker have resisted rot better than those of any other class. Only one named variety, the Clay Rose, was nearly exempt from rot, and only one seedling, No. 49, while the percentage of loss from rot in some cases, notably that of Commercial, was as high as 40 per cent.

2. The figures in Tables II. and III. show that in the case of every variety tried, the largest yields were from the rows treated with wet Bordeaux mixture. Dry Bordeaux mixture gave increases in some cases, but they were not so great in amount in any case nor were results from it so uniformally large as from the application of wet Bordeaux mixture.

3. Wet Bordeaux mixture gave very large increases in most cases, amounting to an average total yield of 231 bushels of merchantable potatoes and an average increase per acre of 86 bushels of merchantable potatoes.

4. The cost of applying wet Bordeaux mixture, as judged by our experience, will vary from $3.00 to $5.00 per acre where three or four applications are made.

5. The difference in yields between the rows receiving no treatment is not more than will often occur between the rows in different parts of the same field.

6. The cost of applying dry Bordeaux mixture is very much less than that of applying the wet Bordeaux mixture, but the results from its use were not nearly so effective. The average increase in yield due to the application of dry Bordeaux mixture was forty-six bushels of merchantable potatoes per acre in the case of Sir Walter Raleigh as against an average increase of eighty-four bushels of merchantable potatoes per acre for wet Bordeaux mixture for the same variety.

7. Paris green in the Bordeaux mixture gave satisfactory results in killing potato bugs. The proportions used were one pound to 125 gallons of Bordeaux mixture.

8. Many varieties of potatoes that we formerly thought good commercial sorts have shown so great a tendency to disease that we must discard them from our list of profitable sorts. However, where the soil is more favorable for potatoes than here, or where the seasons are more favorable, many varieties that have shown a strong tendency to rot and blight might be able to resist these troubles and become profitable.

9. Over 2,000 seedling potatoes have been raised at the Experiment Station during the last five years, but it is questionable if even the best of these are any improvement over the best varieties now cultivated. Several kinds are promising and have been sent out for trial.

CONCLUSIONS AND RECOMMENDATIONS.

The results of the experiments outlined in the foregoing pages and other experience seem to warrant the following conclusions and recommendations.

1. Potato planters should avoid planting those varieties of potatoes that have shown a special tendency to disease. There is a great difference in varieties in this respect.

2. The soil of the older potato growing sections of Minnesota is apparently badly infested with the germs of potato rot, which will probably be troublesome every year, and in exceptionally cool, wet years, like that of 1904, it will cause serious injury.

3. It will probobly pay potato growers, in sections of Minnesota where potato blight and rot have been especially abundant the past year, to spray their potato vines at least three

times with Bordeaux mixture, beginning when the vines are about six inches high and repeating once every two weeks. The aim should be to keep the entire vine well covered with this mixture so at to render it immune to the germs of potato diseases. There are a variety of spray pumps adapted to this purpose. Most of the pumps that work best for applying Paris green in water are adapted to applying Bordeaux mixture. They should have all parts made of brass or copper.

4. Paris green may be applied in Bordeaux mixture without additional expense and with satisfactory results.

5. Potato scab may be successfully held in check by following the precautions and recommendations in this bulletin.

s are
reeks.
with
otato
) this
lying
mix-
with-
fol-
tin.

11

9

10

1

8

2

7

6

5

4

I REED, DEL. ET PINX.

A. HOEN & CO., LITH., BALTO., MD.

THE MEDITERRANEAN FLOUR MOTH.

INJURIOUS INSECTS OF 1904.

BY F. L. WASHBURN, State Entomologist.

THE HESSIAN FLY.

This pest, destined to be with us always in greater or less abundance, which was so troublesome last year, has hardly been heard from during the season just closed. An assistant found some July 21st on rye in Kandiyohi county, and rumors of its occurrence in Marshall, Morrison, Big Stone and Lac qui Parle counties reached us during the summer, but there has been practically no injury whatever in Minnesota to wheat this year by this fly. Owing to its very general absence in localities infested last year, we have been unable to secure pupæ ("flaxseeds") in volunteer wheat, as we did last year, showing the occurence of an extra brood in this state. Two lots of volunteer wheat plants, from eight to ten inches high, were sent us in November; one lot from Marshall county and one from Big Stone county, in both of which counties the fly was thought to be present. Several hundred of these plants were carefully examined, but, contrary to last year's experience, we found no puparia.

Why this pest should have been so extremely abundant last year, causing losses variously estimated at from 10 per cent to 50 per cent and in a few cases 100 per cent, and so extremely scarce this year is easily accounted for. Several minute parasites, also insects, attack it, and as the fly became more abundant, naturally, from the practically unlimited amount of food the numbers of the parasites increased, and finally became so large that the fly succumbed, and in the year following the one in which the flies and also their parasites were exceedingly abundant, we see none. But this great reduction in the numbers of the Hessian Fly removes the food of the parasites, and consequently their numbers decrease also, and this gives the fly a new start, its numbers increasing each year, if climatic conditions are favorable, until the culmination is reached in a year when great damage is done, owing to their excessive numbers. The following year, for the reasons given above, but few are seen. We will prob-

ably have a little trouble with them next summer, and still more the summer following.

The life history, remedies and means of prevention of injury of this pest were fully discussed in the Entomologist's report for 1903.

THE FRIT FLY.

Oscinis soror, Macq.

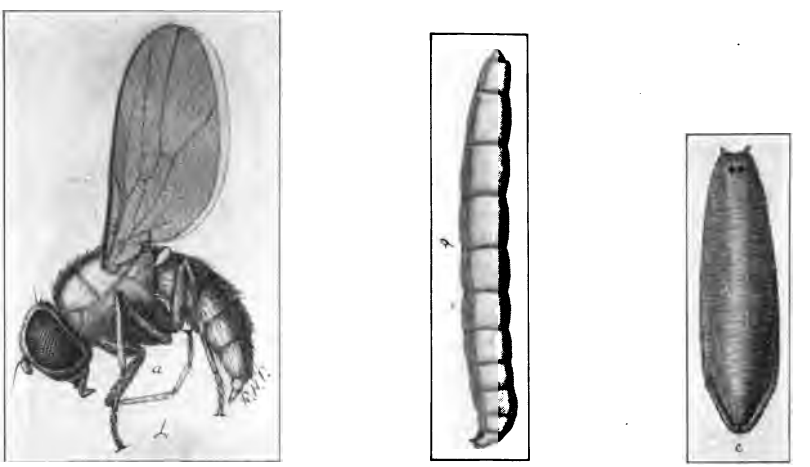


Fig. 1.—Frit Fly: *a*, adult; *b*, larva or maggot; *c*, puparium. Much enlarged. Lugger.

This and the next described species are, without doubt, present in this state. The writer has reason to believe, from various reports of certain injuries to wheat through unknown causes, that both are here in greater or less numbers, though he has not personally met with either one of them.

The Frit Fly, subject of this sketch, is a very small two-winged insect, whose larva or maggot, *b*, is found in the stem of wheat just above the first or second joint. The larva when full grown encases itself in a brown covering, and then resembles somewhat the "flax-seed" of the Hessian Fly. In fact the life history of this pest, and the result of its work so closely resembles that of the Hessian Fly, particularly in the "crinkling down" or falling over of the wheat, that being the first apparent evidence of its presence, that we suspect some of

its work is laid at the Hessian Fly's door. Our illustration will give an idea of the appearance of the larva, puparium and imago or adult insect.

The general remedies given for the Hessian fly will apply in the case of this pest.

THE WHEAT STEM MAGGOT.

Meromyza americana, Fitch.

This insect was reported by Lugger as being abundant here in 1896. In 1895 from 5 per cent to 10 per cent of the crop was ruined in some places, the maggots, according to Lugger, being common from the Red River Valley to the central part of Minnesota. From occasional reports of "white heads" or "bald heads" among the grain this year and last, the Entomologist has every reason to believe they are now with us. These "bald heads" in the wheat are seen when the heads are green, and it should not be difficult for a farmer to tell at once whether the pest is present.

The adult fly is about $\frac{1}{20}$ of an inch long, yellowish, with bronze colored eyes; the back is banded, the underside and legs greenish. The larva or maggot hatching from the whitish egg is pale green, a quarter of an inch long. The transformations are undergone inside the stem.

THE CHINCH BUG.

The Chinch Bug has been conspicuous by its absence this year. Barring an occasional report of a few seen in various localities, no mention of this odorous pest has been made. In Kandiyohi county, on July 21st, we found it working in rye and wheat and in *macaroni wheat*. Early last fall in the Station grounds we found large numbers of dead Chinch Bugs, their demise evidently having been caused by attacks of a fungus, the growth of which was encouraged by the damp weather prevailing at that time. I believe the general prevalence of this condition over the Chinch Bug area in Minnesota has been, in part at least, responsible for our immunity this year. They will be with us again.

In October a report reached this office that a farmer near St. Peter was finding thousands of them on his place, and was killing all he could with kerosene. Inquiry from this office resulted in speci-

mens being sent, which proved to be not Chinch Bugs, but a species of bug belonging to the same family resembling the Chinch Bug some-

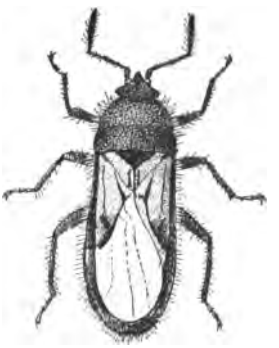


Fig. 2.—Chinch Bug, long winged form. Webster.

Fig. 3.—*Trapezonotus nebulosus*, Fab. Lugger.

what, even having the same bed-buggy odor. This bug is a species of *Trapezonotus*, which feeds for the most part upon weeds, hence is not generally injurious. In some seasons it appears in enormous numbers, filling the minds of the farmers, who think they are the genuine article, with much alarm. We figure a Chinch Bug and a species of Trapezonotus side by side for comparison. Pictures of two other bugs sometimes mistaken for Chinch Bugs are also given,

Fig. 4.—*Lygæus turcicus*, Fab. Lugger.

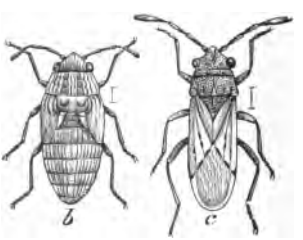


Fig. 5.—*Nysius angustatus*, Uhler. From Riley.

Fig. 4 illustrating *Lygæus turcicus*, and Fig. 5 showing *Nysius angustatus*. The latter is frequently called "The False Chinch Bug" and at times is quite injurious.

The life history of the Chinch Bug and methods of combating it have been fully discussed in our preceding Annual Reports.

THE MEDITERRANEAN FLOUR MOTH.

Ephestia kuehniella, Zell.

Millers have every reason to dread this insect, since it sometimes completely stops the machinery of a flour mill, and when present always calls, sooner or later, for the expenditure of much effort and much money before a mill can be free from its depredations.

The fact that a mill is new is no safe-guard against contamination from returned sacks or the introduction of eggs of the pest in second-hand machinery coming from an infested mill. Nor is a clean mill exempt for the same reason, though regular cleanings have much to do with checking its increase.

In view of the lack of definite information upon this subject among many of our millers, who do not know the best means of fighting the moth, and in consideration of the fact that it is a pest which may appear sooner or later in any flour mill, the Entomologist has included here a chapter on the Flour Moth, fully illustrated, giving its life history, habits, and chief sources of infection, the best remedies and means of prevention.

My predecessor, Dr. Lugger, has never included this pest in any of his bulletins. In April, 1900, he printed in the Northwestern Miller a popular account of the insect, with illustrations. In this article he advised fumigation with bisulphide of carbon, a process which millers do not apparently find satisfactory. Since that time considerable advance has been made in our knowledge of methods of control, which the present report aims to place before the millers of the Northwest. There have been some experiments on the part of the Entomologist bearing upon the effect upon the insect and its eggs of exposure to certain temperatures for a definite length of time, upon the effect of liquid bisulphide of carbon, and of the gas, upon the eggs, and upon the effects upon the larvæ of exposure to a known volume of the gas of C. S_2 for a definite time. The colored plate, excellently true to life, was made under the writer's direction, from actual specimens, as were the original photographs which appear here. The best remedial and preventive measures have been obtained by interviews with practical millers, who have used said measures successfully, the writer

taking the liberty to make certain suggestions as the result of some personal observations and knowledge of the insect's habits. It has seemed desirable also to append short descriptions of some other pests found in flour mills and granaries, most or all of which, when found in mills, are killed by the same treatment which has been found effectual against the flour moth.

Description of Moth, Larva and Egg; Its Life History and Habits.

This moth, named *Ephestia kuchniella*, by Professor Zeller in 1879 in honor of Professor Kuhn of the University of Halle, Germany, is from 2/5 to 3/5 of an inch long, measuring from 3/5 of an inch to 1 inch from tip to tip of expanded wings. Its general color, when freshly emerged from pupa, is blackish gray, the front

Fig. 6.—Mediterranean Flour Moth, three and three-fourths times enlarged. Original.

wings being gray, spotted with black scales, and irregular, angular black lines crossing the wing near the tips. A characteristic W shaped black line will be noted crossing the wing about half way between the tip and base; see colored plate. Fig. 1 on colored plate represents the moth enlarged three times; Fig. 2, the larva which produces the moth, also three times enlarged; Fig. 3, the pupa found in the cocoon, same enlargement; Fig. 4, the head and anterior segments of the larva to show details, enlarged six times; Fig. 5, the posterior segments to show details, enlarged six times; Fig. 6, the dorsal view of head and thoracic segments, showing details of shield, enlarged six times; Fig. 7, abdominal

foot, twelve times enlarged, showing crown of hooks; Fig. 8, freshly made cocoon, formed in flour, showing larva within, three times enlarged; Fig. 9, one fore wing, showing venation, six times enlarged; Fig. 10, a hind wing, showing venation, six times enlarged; Fig. 11, a freshly laid egg, enlarged twenty-five times. The hind wings are thin, translucent and silvery. Both fore and hind wings are heavily fringed. All the above figures refer to the colored plate, not to the illustrations in text.

The females are a little larger than the males, but the coloration of the wings of both sexes is alike. The females have a characteristic habit, upon emerging from the pupa, of remaining for hours with tip of abdomen and head raised above the level of the rest of the body; see Fig. 15 in the text. Egg laying, which lasts several days, takes place, as a rule, immediately after copulation, each female averaging about 200 eggs. These eggs may be placed anywhere, in cracks, in flour, in spouts, purifiers or other machinery, in sacks containing flour or meal, in any place, in fact, to which the moth has access.

Fig. 7.—Larvæ of Mediterranean Flour Moth, four times enlarged. Original.

The larva, sometimes called "the worm" (see colored plate, also Figs. 7 and 15 in the text), is about 1/25 of an inch when first hatched, from white to pink in color, with a reddish brown

head; a few very small hairs are scattered over the body. The larval life is about forty days, and when full grown it measures from 1/2 to 3/5 of an inch in length. The color becomes more pronouncedly pink than in the young larva. We have noted in the laboratory that individuals vary in color, some even appearing to have a greenish tint. There are six true legs near the anterior end of the body, and four pairs of rather long fleshy legs on the abdomen. With a lense one can see that each one of these abdominal legs is provided with a circle of small hooks at the end (Fig. 7, colored plate). There is also a pair of so-called caudal legs at the extreme posterior end of the larva.

Little blackish or brownish spots, each bearing one or two hairs, are formed over the body, three on a side in each segment. At the anterior and posterior ends, the spots which are lower down on the side are larger and more conspicuous than the others. One spot on each side, just back of the head, is formed by an incomplete ring, its circumference being broken toward the head. A careful study of the colored plate (Figs. 4 and 5) will help one in recognizing these details. Just back of the head (see Fig. 6 of colored plate) is a conspicuous reddish brown plate or shield, divided into two parts by a middle pale line.

The larva has a pernicious habit of secreting a silken thread wherever it goes. When traveling back and forth over a smooth surface this results in a sheet of silken tissue of considerable strength, much like that seen in Fig. 6 in text, which illustrates the work of the worms on a piece of bolting cloth covering a breding jar in our laboratory. When, however, the larvæ are crawling through flour or meal the result is, as many millers know to their cost, a mass of flour held together by countless threads, forming a webbing which clogs spouts, elevator legs and other machinery to such an extent frequently as to completely stop the work of the mill. (See Fig. 10 in text.)

This larva may find its way into a perfectly clean mill in returned sacks, unless said sacks are treated in some way before being placed in mill. Second-hand machinery from an infested mill may harbor larvæ or eggs. When full grown, which takes, as we have said, about forty days, the larva crawls about restlessly until it finds a place to spin its cocoon, about 1/2 inch long, within which it transforms

to a pupa (Fig. 8 of colored plate; see also *b* of Fig. 15). If this cocoon is spun in flour or meal it is matted with the fine particles, as shown in the colored plate. (See also Fig. 9 in text of report.) The pupa is reddish brown, a little less than 1/2 inch long, and about 1/10 of an inch wide. The last segment of the body of the pupa is provided with a few short hairs. The length of the pupal stage within the cocoon is evidently from ten to twelve days.

The time elapsing between laying of egg, hatching of same and transformation of larva into a pupa, and the emergence of the moth, is evidently between sixty and seventy days, or an average of nine weeks for one generation.

Fig. 8.—Egg of Mediterranean Flour Moth, fifty times enlarged. Original.

The egg, oval in shape, when first laid white and almost smooth, later becoming brownish and wrinkled, is just visible to the naked eye. The eggs hatch in nine or ten days. Two freshly laid eggs, measured in the laboratory, were each .6 millimeters long by .35 millimeters broad, or about 1/42 of an inch long by 1/63 of an inch broad. We figure one of these enlarged twenty-five times on colored plate (Fig. 11). Also same egg in text, Fig. 8, enlarged fifty times.

Eggs, as well as larvæ, may be brought into a perfectly clean mill in infested material, thus sowing the seed of trouble; sacks, barrels, and second-hand machinery from some infested mill being the chief sources.

One female which we had under observation in the laboratory at St. Anthony Park began egg laying February 9th, continuing until and including February 14th, five days, laying during that period 247 eggs. Copulation lasts a long time and evidently one

female may mate with several males, laying eggs between the different matings.

As regards the food habits of this insect; rice flour is a dainty dish for the larvæ, as is flour made from buckwheat. Any infested mill which keeps flour in sacks before shipping may hear sooner or later from the consumer or retailer that "the flour is wormy." This is caused by the female moth pushing her ovipositor through the sack and laying her eggs in the flour inside. Crackers, germea, rolled wheat, oatmeal and corn meal are all said to suffer.

The moth is evidently a continuous breeder in warm localities, in warm mills for instance. It is a well known fact that cold retards and warmth hastens its development, millers sometimes taking advantage of the first point to keep the pest in check.

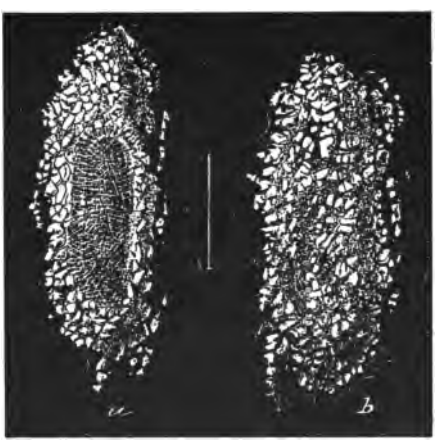


Fig. 9.—*a*, cocoon from below showing pupa through the thin silk attaching cocoon to some surface; *b*, same from above, enlarged.—Riley and Howard in Insect Life.

Dr. Fletcher of Canada, says in connection with the outbreak there, that there are probably two normal broods, one in the spring, another in the autumn, but he thinks he raised as many as three distinct broods in a warm room during the winter. F. H. Chittenden, of Washington, claims that in the warmest weather in that locality the life cycle occupies only five weeks.

Preventive Measures.

Cleanliness:

Because a mill is clean or new is no reason why the moth cannot be introduced, if sacks containing eggs or larvæ, or second-hand machinery from an infested mill are allowed to enter. At the same time, scrupulous cleanliness has much to do with immunity, for eggs and larvæ are dislodged by processes involved in the term, and not allowed to develop. Every mill, it would seem, should, and many do, have cleaners or sweepers, whose sole duty

Fig. 10.—Flour matted together by web spun by larvæ, one-half natural size.—Lugger.

it is to see that every floor and all machinery, purifiers, spouts and elevators are kept clean. Naturally such an employe or employes should have some knowledge of insects found in flouring mills.

Fumigation House:

The writer is convinced, from talking with millers who have had experience with this pest, that the chief source of contagion lies in receiving into the mill returned sacks, and also second-hand machinery from an infested mill, which may harbor the eggs or

larvæ. Some mills, in order to avoid infection, will not take back old sacks. If a milling company must do this *such material should be thoroughly treated before being allowed in the mill.* A fumigation house, or room, might be constructed, where sacks or machinery could be fumigated. If sacks have been in transit for more than nine days, and during that time free from all sources of contagion,

Fig. 11.—Silk felt spun by larvæ in crawling across bolting cloth on top of breeding jar; showing also larvæ, pupa, cocoons, and moths somewhat reduced. Original.

all eggs which may have been originally in the package have hatched, hence, one need not seek for a treatment which will kill them (the eggs), but only for such as will kill the worms which have hatched from the eggs. Carbon bisulphide is the best and safest fumigating material at our disposal, and could be well used

in this instance. The gas generated by this liquid, when mixed with air, is highly explosive, and no lighted match or lamp, or lighted cigar or pipe should be brought near it. As it is definitely known just how much of this liquid is required to create a "death atmosphere," the cubical contents of this room, or better, house, should be accurately determined. From experiments tried with this gas by the writer, he would suggest one part of liquid for every one thousand parts of atmosphere. To determine, if possible, whether this strength of gas would penetrate to the center of the bale in killing quantity, the Entomologist inclosed "worms," pupæ, and moths in vials loosely stoppered with cotton. These vials were placed in a flour sack, which was tightly rolled up. This bundle was placed in a second flour sack, which in turn was tightly rolled, and the package placed in a burlap sack and rolled again. This compact bundle with the worms in the very center was then exposed for three days, in a tight iron box, to fumes of carbon bisulphide, one part of the liquid to 1,000 parts of atmosphere. This killed every "worm," pupa and moth. The fumigation house or room *must be absolutely tight to retain the gas.* The liquid should be placed in shallow trays, and the room closed for at least three days if the sacks are left in the bale. A longer time than that, under such conditions, would be highly desirable. If the worm cannot be reached in the bale by fumigation for three or five days with the above strength, millers should be willing to open up the bales. This involves extra handling, and means added expense, but might be an imperative necessity, for *work not thoroughly done in this connection represents time and money thrown away.* After fumigation the house or room should be thoroughly aired before allowing a light of any kind inside.

The gas from bisulphide of carbon will sink through a mass of wheat in a large bin, and also through a chestful of woolen clothing, if in each case the liquid is placed in shallow dishes on top of the wheat, or clothing. It is probable, therefore, that it will penetrate a loose bale of sacks. Possibly heat alone might be profitably used in this connection.

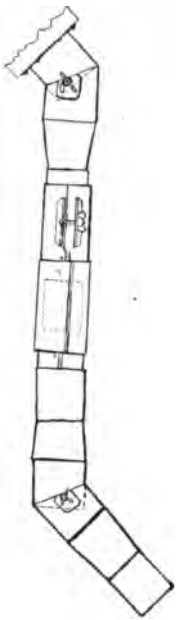


Fig. 12.—Adjustable metal spout. —From W. G. Johnson's Report.

Cylindrical Metal Spouts:

L. C. Schroeder of Olean, N. Y., has invented and patented a metal spout, shown in Fig. 12, which is reported as giving satisfaction, since it presents a smooth surface within, and no corners, thus being a great improvement, as regards the flour moth, over the wooden spouts which afford such an excellent opportunity for the larvæ and the laying of eggs. It is claimed that the metal spouts cost less than those made of wood. This principle, for reasons which will at once be obvious to practical mill men, cannot well be applied to the elevator legs, although it is said that the same party has patented a metal elevator leg.

Belt Brushes:

Since metal elevators cannot be economically introduced into our mills as they are now constructed, an excellent device for keeping the wooden elevators clean, if we are to believe statements of those who have used them, consists of an elevator brush as shown in Fig. 13, constructed as follows:

"To make the brush, take a piece of 1 1/2-inch plank of the same dimensions as the elevator cups, and fasten bristles to three sides. The side A is fastened to the elevator belt with flat-headed bolts running through the plank, as shown at B, B, the bolts being 1/4 or 3/8 of an inch. The bristles on the sides C, C should be 3/4 of an inch long, but those at D should be longer, so that they will give a good brushing to the outer side of the elevator. The brush is easily made, and the miller can make it of any size to fit his elevators."

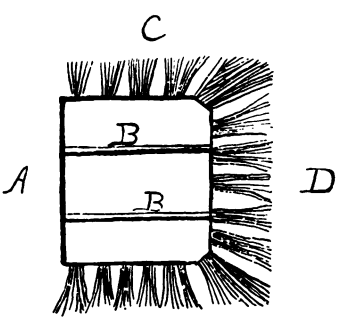


Fig. 13.—Elevator Brush.—From W. G. Johnson's Report.

Co-operation:

Co-operation on the part of all millers, particularly where mills are in the same district, *seems absolutely necessary.* If one fumigates returned sacks, and goes to the expense of freeing his mill of this pest, all should. Otherwise, moths from the untreated mills are almost sure to enter a cleaned mill, rendering the work of the more careful miller, in this connection, of little value. Screening windows and doors might be resorted to, and form at least a partial protection, though occasioning additional expense. Observations at the Experiment Station indicate that the moth cannot pass through the mesh of ordinary wire mosquito netting (144 meshes to the square inch).

Freezing:

This most excellent and inexpensive method is available for Minnesota millers during almost any winter. The spouts, elevator legs, purifiers and all machinery should be first freed from masses of webbed flour, etc., left open (this does not mean the unscrewing of the sides of the elevator legs or spouts), and then all windows thrown open for a period of four or five days, after which windows should be closed and heat turned on. The importance of exposure to heat after the freezing must not be underestimated. The owners of one infested mill stopped their machinery this winter, opened all machines, spouts and elevators to allow access of cold air, and then kept their windows open for a period of four days. This was done in a time of extremely severe weather, the thermometer ranging at the time from ten degrees below zero to thirty-two degrees below, the average temperature of the mill during that period being five degrees below zero. At the expiration of this period windows were closed and heat turned on. Some larvæ ("worms") and moths collected, and, subjected to examination for several days, did not revive, killed by the extreme cold, aided possibly by the sudden change from warm to cold and cold to warm. Eggs subjected to the above freezing, and kept under observation for fifteen days and over, did not hatch; nor did the weevils, and other pests found with the Flour Moth, survive this treatment. These statements were made to the writer; they are not his observations.

However, while millers in Minnesota can secure at some time, during almost any winter, a temperature sufficiently low to kill by freezing, yet such a condition is not always present, even in Minnesota, when wanted (if outbreak occurs in early spring and summer for instance), and surely millers in the South could rarely, if ever, take advantage of this method. The bisulphide method (not fumigation) must of necessity have to be resorted to, when temperature conditions are not favorable for freezing.

In one or two mills subjected to this freezing process fire had to be kept in the basement, and a sufficiently low temperature could not be secured, the treatment in consequence resulting unsatisfactorily. See also results of experiments by the Entomologist on pages 29 and 30. In one mill, however, where the entire mill was exposed to severe cold for eight days or more, the process was an absolute success. It must be noted, however, that if millers in close proximity do not co-operate in work against this moth, the pest will reappear even if it is to all appearance eradicated from a mill. Further, as noted below, eggs are not always killed by low temperature.

Observations and Results of Experiments by the Entomologist.

Mating and egg laying; time elapsing between laying of egg and hatching of same.

Pairing is evidently protracted, one isolated pair under observation remaining *in copulo* four days. Ovipositing in one case lasted six days, a female beginning egg laying on February 9th and continuing until the 15th, on which date she died. During this time *the one female* laid 247 eggs. These eggs began hatching on the 18th, nine days after the first were laid, a recording thermometer registering an average temperature of 70 degrees Fahr. in the room during that time. Two freshly laid eggs were measured, each measuring .6 millimeters in length by .35 millimeters in breadth, or, in round numbers, 1/42 of an inch long by 1/63 of an inch in breadth. Three other laying females deposited respectively 242, 157 and 239 eggs.

The flight of the Moth: The question as to whether moths would fly from one mill to another suggested observations along this line. The insects if left to themselves did not fly in the morning. Late in the afternoon and in the evening after the light was turned on, an assistant reports them flying freely across the room, although not attracted to the lights, but rather avoiding them. Observations elsewhere indicate that they will fly at least 110 feet, and probably farther.

Can the Moth get through wire mosquito netting? Moths confined for several days in a cage made of wire netting, 144 meshes to the square inch, did not escape, dying within the cage.

Effect of liquid Carbon Bisulphide on eggs, larvæ, pupæ and moths: One contact for a few seconds with this liquid killed eggs, young and full-grown larvæ and moths. The pupæ were not killed immediately, but died later.

Least volume of Carbon Bisulphide (CS_2) and least time of exposure necessary to kill full-grown larvæ and moths by fumigation:

Condition of Insect.	Strength of Gas.	Time Exposed	Results.
Full-grown larvæ..	1 Part liquid CS_2 to 1,500 parts atmosphere	1 hr. 40 min.	Killed.
Full-grown larvæ..	1 Part CS_2 to 3,000 parts atmosphere..	1 hr.	Killed.
Full-grown larvæ and moth.....	1 Part CS_2 to 6,000 parts atmosphere	2 hrs.	Killed.
Full-grown larvæ and moth.....	1 Part CS_2 to 12,000 parts atmosphere.....	3 hrs.	Killed.

Effect of exposure of moths, eggs, larvæ and pupæ to known low temperatures for definite lengths of time:

Lot No. 1. Exposed out of doors in breeding jar, for three days, to a temperature ranging from 18 degrees above to 12 degrees below zero. All killed.

Lot No. 2. Placed in cold storage at 32 degrees for four days. Living at expiration of that time.

Lot No. 3. Placed in cold storage at 14 degrees above zero for four days. A few worms survived.

Lot No. 4. Placed in cold storage at 6 degrees for four days. "Worms" survived.

Lot No. 5. Placed in cold storage at 1 degree above zero for four days. All killed.

Lot No. 6. Placed out of doors for four days, temperature ranging from 18 above to 21 below zero. One or two worms survived.

It would seem, then, from the above, and from the experience of millers cited on page 28, that the "freezing process" to be thoroughly effective must be most thorough. Mills should be so constructed that all water pipes can be emptied, allowing all parts of the mill to get extremely cold. Further, since we know that a long continued even cold temperature is not always fatal to insects (note the hibernation of Minnesota insects, for example), but that exposure to cold and thawing alternately is fatal, we would suggest that millers in this

work arrange to alternate the extremely cold temperature with warm, that is, after the first exposure to cold for a few days, allow the mill to become warm and follow this with another cold exposure. Repeat the operation two weeks later. The above lots, Nos. 1 to 6, were masses of matted flour containing the worms, the latter being thus somewhat protected.

The Entomologist also tried the following experiments:

EGG. Effect of exposure to fumes of Carbon bisulphide.	Exposure to fumes of CS_2 (1 part liquid CS_2 to 10000 parts atmosphere) for 42 hours failed to kill eggs.
	Exposure to fumes of CS_2 (1 part liquid CS_2 to 1000 parts atmosphere) for 42 hours failed to kill eggs.
	Exposure to fumes of CS_2 (1 part liquid CS_2 to 5000 parts atmosphere) for 6 hours failed to kill eggs.
Effect of exposure to fumes of Carbon bisulphide.	Exposure to fumes of CS_2 (1 part liquid CS_2 to 5000 parts atmosphere) for 12 hours failed to kill eggs.
	*Exposure to fumes of CS_2 (1 part liquid CS_2 to 5000 parts atmosphere) for 24 hours failed to kill eggs.
Effect of Low Temperature.	6½ days' exposure to 12 degrees above zero did not kill all the eggs.
	6½ days' exposure to 3 to 5 degrees above zero killed all eggs.
	36 hours' exposure to 3 to 5 degrees above zero killed all eggs.
	36 hours' exposure to 3 to 5 degrees above zero failed to kill all the eggs.

These eggs were kept under observation for two to three weeks. In every case control sets were preserved.

LARVÆ or "Worms." Effect of exposure to fumes of Carbon bisulphide.	Exposure to fumes of CS_2 (1-5000) for 24 hours killed larvæ.
	Exposure to fumes of CS_2 (1-10000) for 42 hours killed larvæ.
Effect of Low Temperature.	6½ days' exposure to 3 to 5 degrees above zero killed larvæ.
	6½ days' exposure to 12 degrees above zero killed larvæ.
	36 hours' exposure to 3 to 5 degrees above zero ("worms" just hatching) killed larvæ.

Newly hatched larvæ will live from two to three days without food.

PUPÆ.	
Effect of exposure to fumes of Carbon bisulphide.	*24 hours' exposure to (1-5000) killed pupæ.
Effect of Low Temperature.	6½ days' exposure to 3 to 5 degrees above zero killed pupæ. 6½ days' exposure to 12 degrees above zero killed pupæ.
MOTHS.	
Effect of exposure to fumes of Carbon bisulphide.	*24 hours' exposure to (1-5000) killed moths. 6 hours' exposure to (1-5000) killed moths. 42 hours' exposure to (1-10000) killed moths.
Effect of Low Temperature.	6½ days' exposure to 3 to 5 degrees above zero killed moths. 6½ days' exposure to 12 degrees above zero killed moths.

CONCLUSIONS AND SUGGESTIONS.

From the result of these experiments, the following conclusions are drawn:

Spraying eggs, larvæ, pupæ and moths with liquid CS_2 is fatal.

Attempting to kill eggs by exposure to fumes of CS_2 is apparently not practical. Hence when fumigation of a mill is resorted to (unaccompanied by spraying) the process should be repeated ten days or later after first fumigation in order to kill the larvæ hatching from eggs which went safely through the first fumigation.

Full grown larvæ and moths (and probably pupæ) can be killed by exposure for 42 hours to fumes of CS_2 (1 part liquid CS_2 to 10000 parts of atmosphere).

Larvæ, pupæ and moths in the center of tightly baled sacks can be killed by 24 hours' exposure of fumes of bisulphide of carbon (1 part liquid CS_2 to 5000 parts of atmosphere). Forty-eight hours' exposure where possible would be the preference of the writer. Fumigation is, therefore, practicable treatment for infested sacks in bale.

*In this experiment, eggs, larvæ, pupæ and moths were enclosed in the very center of a tightly packed bale of flour sacks before being placed in fumigation box, simulating as nearly as possible the conditions which would exist in fumigating sacks in bale. As noted, this kills moths, pupæ and larvæ, but not the eggs.

An exposure of 6½ days to a temperature of 3 to 5 degrees above zero kills eggs, larvæ, pupæ and moths. In view, however, of certain experiments in mills where there are many protected corners and cracks, and where eggs, worms and pupæ are found in matted flour, any attempt to use the "freezing process" in a mill calls for from six to eight days' exposure to a temperature as low as it is posible to obtain, certainly as low as zero in every part of the mill, to be perfectly successful. As intimated above, if alternate freezing and thawing, followed immediately by a second freezing, can be secured, the best results will be obtained.

Spraying with Bisulphide of Carbon.

This method, which has been very successfully practiced, consists in forcing the liquid by a syringe made for the purpose into all the machinery infested, inside of spouts, etc. Parts of the mill or fittings which do not come in contact with grain or products made from same can be well treated with kerosene, squirting it into cracks between joists, and into cracks between joists and iron braces, into cracks about windows, along baseboards, and into cracks in floor, walls and ceilings. It is evident that this must be done most thoroughly to reach all eggs or worms concealed in such places. Fig. 14 represents a syringe used for spraying the bisulphide or kerosene. It may be made of iron pipe, of brass, or of tin. It is eighteen inches long, two inches in diameter, and will hold, at those measurements, about one quart. The rose is detachable, unscrewing from the barrel, and it (the rose) is filled on the end with many very small holes, as small as the finest needle, in order that the liquid may not be wasted. In filling the syringe the rose can be unscrewed and the end of the syringe immersed in the can holding the bisulphide, or, and this is much better, a little hole covered by a screw cap, not shown in the illustration, may be made on the side of the rose and the liquid drawn in through that. This is by far the best plan, for when the rose is unscrewed and the liquid drawn into the syringe it necessitates the holding of the filled barrel upright in order to screw on the rose, under which circumstances the liquid will run out below, near the handle, unless the piston rod fits very snugly.

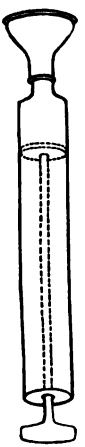


Fig 14.

When the syringe is used with kerosene, the rose is unscrewed and a small nozzle with one aperture, considerably larger than the holes in the rose, put on in its place. This is used when treating cracks in floors, etc.

Before the work with carbon bisulphide or with kerosene is begun, elevator legs, spouts, purifiers and all infested machinery must be thoroughly cleaned, in other words freed from all matted flour. When the spouts are lined with tin, affording a retreat for the worms beneath the tin, the wooden sides must be removed to get at the culprits. Swabs of cotton waste or pieces of old sacks should be run through the elevators (stuffing these swabs into cups), taking off caps of elevators and having men, stationed at the top, take out the ascending swabs when they reach them, and put in other swabs in the descending leg. The elevator brush, Fig. 13, might be well used in this connection, or brushes made from the same material as the belting, frayed on three sides and riveted to cups. All conveyors should be taken out and thoroughly cleaned. Purifiers and reels and insides of conveyor boxes, all machinery in fact, should be thoroughly sprayed with carbon bisulphide after having been cleaned. The cloth tubes on dust machines should be burned. In treating elevator legs with carbon bisulphide, the same method can be used as in cleaning, described above, saturating the swabs with the liquid. A swab should take up about one pint of the liquid.

All this means the expenditure of time, and money for material. An ordinary sized mill may, in this process, use from 1,000 to 1,500 pounds of carbon bisulphide, or even more, to say nothing of the large amount of kerosene employed. We are reliably informed that bisulphide of carbon can be purchased for 6½ cents per pound of a dealer in New York City and St. Louis. This price does not include container, credit for which is allowed upon its return.

Caution: The gas generated by bisulphide of carbon is inflammable. Therefore, while it is being used and until the mill has been thoroughly aired after treatment, **no light of any kind should be allowed in the mill. A lighted cigar or pipe, lantern, or lighted match, if brought into the mill when filled with gas, might cause an explosion.**

Effect of the Gas on Human Beings: This liquid can be safely handled by workmen in the mill if they will take the precaution to go at once into the open air when they feel any bad effects from inhaling the gas. The mill, during this process, should be tightly closed to make the work more effective, and in consequence is filled with fumes. If these fumes are inhaled by the men for some length of time without the precaution above mentioned of going frequently to the fresh air, temporary nausea and sickness may result, while prolonged exposure to dense fumes in a tight room might result very seriously. Nature, however, gives one warning in plenty of time to avoid danger. Then, too, in a case which came under the writer's observation, men working with the stuff became more or less immune, and one individual was hardly affected at all.

As is evident, the treatment of a mill in this way should be in charge of a reliable and competent man of intelligence, one fully posted as to the nature of the chemical his men are handling.

Methods Which Have Been Tried and Found Ineffective or Less Desirable than the Preceding.

Fumigation with Bisulphide of Carbon: Although this has been the common practice in the past, and is generally recommended in cases of attack of this insect, actual experience with its use does not bear out the recommendation, in that it does not appear to kill the moths or worms under the conditions which prevail in almost every mill. It may be effective against other insect pests with which flour mills are troubled, thus giving rise, from published report, that it is effective also against the Mediterranean Flour Moth, but we know of at least three instances where it was tried in large mills and proved valueless.

The process consists in placing pans of carbon bisulphide on the different floors, using a definite amount of the liquid (about one part to every one thousand parts of atmosphere), first making the room as tight as possible, opening up all spouts, spindles and other apparatus in which the moth or its larva is found. The chief obstacle here is the almost utter impossibility of making the large rooms air tight. Then, too, as evidenced by the testimony of a Pennsylvania miller a few years ago: "When placed in plates it

does not evaporate quickly enough to produce the death atmosphere required." This firm used three hundred soup plates half filled with bisulphide and distributed throughout the mill, besides saturating balls of cotton with the same and placing them in all reels and purifiers. The mill was left from Saturday night to Monday morning, and although thousands were found dead, many thousands more appeared from cracks and corners after a few days.

Sulphur: The burning of sulphur not practical, besides injuring the flour in sacks in the mills.

Steam: Not practical, requiring too elaborate preparation, and too frequent application; seriously injuring grain or flour, and rusting machinery.

Kerosene: Good for washing walls, machinery, floors, etc., where it cannot injure flour or grain. See reference to kerosene on page 32.

Solution of Soda and Water: Used strong for washing inside of machines.

Buhach, or Persian Insect Powder: Has been burned in a mill with only partial success, and expensive.

Ammonia: Not successful.

Hydrocyanic Acid Gas: Coming quite generally into use. Placed in this list on account of danger of application unless in the hands of experienced parties. Deadly to all animal life. Prof. W. G. Johnson, author of "Fumigation Methods," says he has freed a number of mills of the Mediterranean Flour Moth by the use of this gas.

Corrosive Sublimate: Not desirable.

Lime: Whitewash to which a little glue has been added excellent for ceilings and walls; the tendency to rub off can be stopped, it is said, by adding a handful of common salt, and a half teacupful of lard to each gallon of wash, which should be thoroughly strained before being used.

Sulphuric Acid: Not recommended.

Tobacco: Not particularly effective, either as smoke or infusion.

Flour Paste: Compound of flour, water and vinegar and boiled by steam found to attract insects when paste was at a certain stage of fermentation. Moths fall into paste and perish. Too expensive, and has to be renewed every few days.

Vinegar and Water: Not desirable.

Molasses and Vinegar: Will attract and destroy some moths.

"Tanglefoot" or Sticky Fly Paper: Something like the sticky mixture used to coat Tanglefoot fly paper can be made without much expense. Hundreds of moths have been caught in a single night on sticky fly paper. The paper should be placed in such places as are frequented by moths for egg laying, notably on piles of sacks filled with flour, etc. It is evident that if one can catch many female moths before egg laying, the process is well worth the expense incurred, and is a desirable measure.

Coal Tar: Not desirable.

Coal Tar and Vaseline: Better than coal tar alone. This and preceding used in the same manner as "Tanglefoot."

Hand Picking: Not feasible.

Hay Ropes: A German miller is the authority for the statement that ropes of new mown hay placed about the mill in coils afford attractive retreats for the moth. These coils were burned with the contained moths each week.

High Temperature: Exposure to a temperature of 120 to 130 degrees Fahr. for two or three hours is claimed to be fatal to the larvæ in the flour, and the same temperature for five or six consecutive hours is said to kill the eggs. This may prove of practical utility.

Natural Enemies of the Flour Moth.

Mr. Johnson describes in the American Miller for November, 1895, the discovery of one parasite in America, *Bracon hebetor*, Say. In Europe *Bracon brevicornis* and *Chremylus rubiginosus* are mentioned as parasites. In 1901 and 1902 Dr. Fletcher bred two parasites from the Flour Moth, *Idechthis ephestiæ*, Ash., and one unnamed. Poultry, seemingly fond of the "worm," has been kept in warehouses with some good effect, though the hens appeared to tire of the diet. Mr. Johnson records the eating of a large number of pupæ by a mouse, but no millers care to introduce mice into their mills for this purpose. Mice, as all entomologists know, readily eat insects, whether alive, or dead and pinned.

Tribolium confusum, a little brown beetle, a common pest in flour mills, and discussed in this connection elsewhere in the report, has been known to devour the pupæ of the flour moth.

The so-called "bolting-cloth beetle" (*Tenebroides mauritanicus*) of California eats larva and pupa of flour moth and larva and adult of *Tribolium*.

History of the Moth and Its Geographical Distribution.

The origin of this pest cannot be stated definitely. It is probable that it always has been a widespread species, but not arousing attention until, atracted by flour and related products in mills, it changed its habits and became prominent as a menace to the flour milling industry. When first named by Zeller it was supposed by him to have been introduced from America, and it was so stated, but it was found by him in an inland town of Germany, Halle, before he knew of it at any seaport, and the same thing could be said of its first officially reported appearance in France. One miller has said with emphasis that he knew of its occurrence in Paris as early as 1840, and another claims that it was in Constantinople in 1872, both statements, coming from different sources, affording additional proof that it is not of American origin, where it was not officially reported until 1889 (Canada). There is evidence that it was in America a few years previous to this date, not, however, until long after it was known in Europe. In 1885 it was declared to be a dreaded pest in many Mediterranean ports, though no statement was made as to how long it had existed in those places. It is reported from Chili, from Mexico, New Mexico, from the island of Jamaica, and in 1890 what was evidently this species was reported from South Africa. A practical miller, who has since had experience with the pest in California, asserts that it was in Schleswig-Holstein, Germany, in 1858, although the first recorded observation from Germany is in 1877. Freight cars and ships may easily be the means of carrying it, either as egg, worm or moth, to regions remote from the scene of its earlier appearance.

It would be impossible to review in this publication the extensive literature upon this pest, nor is it necessary to list the bibliographical references. In order, however, to give an idea of its spread which is approximately correct, we list the following dates taken chiefly from Johnson's bibliographical list, and under each date insert the locality or localities where the moth appeared that

year, as far as reported. In some instances, the outbreak may have been one or two years preceding the report.

1877.

Outbreak at Halle, Germany.

1879.

Outbreak of 1877 referred to and insect named by Zeller.

1884.

Belgium. Supposed then to have been introduced in an American cereal. Reported also on lower Rhine.

1885.

Reported at Bremervörde, Germany.

1886.

Appeared in England.

1887.

London.[3] Trieste. In the 39th Annual Report of New York State Museum of Natural History, J. A. Lintner publishes his reply to an inquiry of the German consul general at New York City, asking for information about the Flour Moth. He states that he (Lintner) knew of no such insect in America. This is believed to be the first published statement in America regarding the pest.

1888.

T. D. A. Cockerell in the Entomologist for November, 1888, page 779, declares that certain larvæ found in flour which came from America may have come from infested Trieste flour in the same warehouses.

1889.

First report of its occurrence in North America, in Canada. May have been present a few years earlier. Reported as being in very destructive numbers in England.

1890.

Still present in England and spreading. A pest reported from South Africa which, from its habit, must have been this insect.

1892.

California.

1893.

On the increase in California.

1894.

Still present in California. Reported from New York State. from North Carolina, and said to have been found in meal and bran from Mexico on exhibition in Chicago.

1898.

New York State. Pennsylvania. (Reported as having been present there for three years.) New outbreak in Canada.

1899.

Wisconsin.

1900.

Wisconsin.

1901.

Minnesota.

1903.

Minnesota.

1904.

New localities reported in the following states: California, New York, Indiana, Illinois, Iowa and Pennsylvania.

The Flour Moth is found, in addition to the above localities, in Colorado, Montana and other states; it is, in fact, of very general distribution.

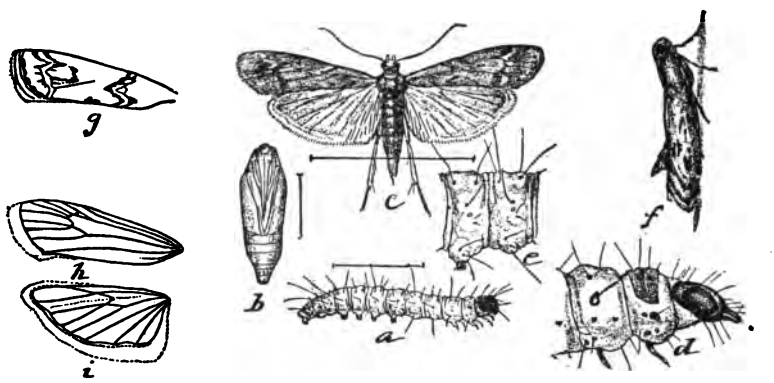


Fig. 15—Mediterranean Flour Moth; *Ephestia kuehniella*, Zell.: *a*, larva; *b*, pupa; *c*, adult, enlarged; *d*, head and thoracic joints of larva; *e*, abdominal joint of same, still more enlarged; *f*, moth from side, resting; *g*, front wing, showing more important markings; *h*, venation of fore wing; *i*, venation of hind wing, somewhat enlarged. (*a*, *b*, *c* and *e*, Riley & Howard in Insect Life; *d*, *f*, *g*, *h* and *i*, after Snellen.)

SOME OTHER INSECTS FOUND IN FLOUR MILLS OR AFFECTING STORED GRAIN.

Many of the following insects are also found in flour mills, and are frequently spoken of collectively as "weevils," which term is also sometimes, though not often, applied to the Mediterranean Flour Moth. That this is a wrong appellation is evinced by the fact that only two of the insects listed below are true weevils.

Treatment which is successfully directed against the Flour Moth will kill any of the following insects, when occurring in the mill treated.

The Granary Weevil.

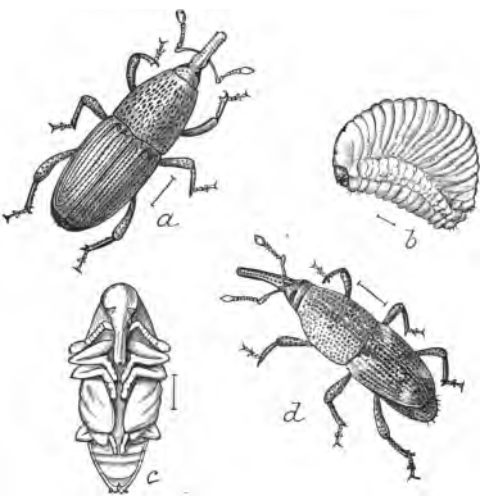


Fig. 16.—*a, b, c,* different stages of the Granary Weevil (Calandria granaria), *d,* Rice Weevil (C. oryza).—F. H. Chittenden, Division of Entomology, U. S. Department of Agriculture.

Fig. 16 illustrates this species and its congener, the Rice Weevil. The hair lines by each show the natural size of the insect. The female Granary Weevil punctures a grain of wheat with her snout and lays an egg in the opening, the larva after hatching feeding upon the interior of the kernel. There may be from four to six broods of the Granary Weevil during the year, depending on the temperature. It is estimated that one pair, under favorable circumstances, will produce six thousand descendants in a year. This beetle is of a shining brown color. It cannot fly. Its cousin, the Rice Weevil, is a dull brown, its back provided with four reddish spots. It has well developed wings. In the southern states this latter weevil is a serious pest.

The Angoumois Grain Moth.

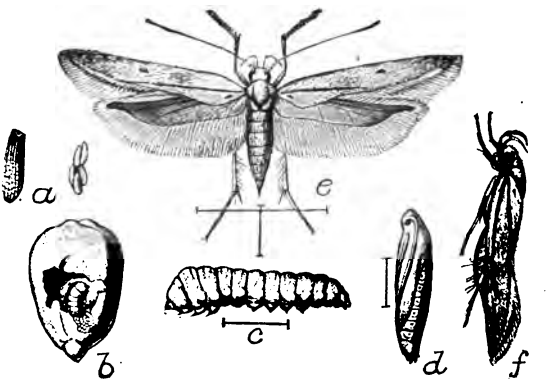


Fig. 17.—Angoumois Grain Moth, *Sitotroga cerealella*: *a*, eggs; *b*, larva at work; *c*, larva, side view; *d*, pupa; *e*, moth; *f*, same, side view.—F. H. Chittenden, Division of Entomology, U. S. Department of Agriculture.

This pest is shown in Fig. 17. It is named from a province in France, where is has been known since 1736. It is claimed to have been found in America since 1728. More injurious in the South than in the North, it attacks not only wheat in the field and bin, but is partial to all the cereals. It is a brownish moth, resembling in a general way the Clothes Moth in size and appearance.

The Indian Meal Moth.

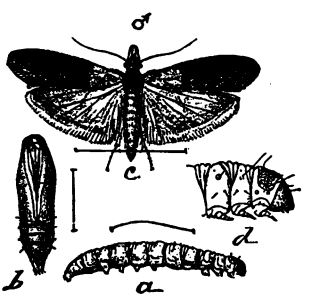


Fig. 18.—*Plodia interpunctella*: *a*, larva; *b*, pupa; *c*, adult male, enlarged; *d*, head and thoracic joints of larva, still more enlarged.—Riley and Howard in Insect Life.

This insect, resembling somewhat the Mediterranean Flour Moth, not only feeds upon grain, flour, meal and bran in mills, but is seen in stores and elsewhere, where it affects spices, herbs, roots, seeds, dried fruit, etc.

The larvæ or "worms" which produce these moths fasten together the kernels of grain, or the seeds or other material upon which they are feeding, with silken threads. These masses, fouled with their excrement, greatly impair the value of the infested foodstuffs. It is said to have from four to six or nine broods annually, depending upon the temperature of the rooms where it is found. It is shown in its various stages in Fig. 18.

The Meal Snout Moth.

This is a brownish moth, having darker brown patches at the outer edges of the front wings. Fig. 19 gives a very good idea of its appearance; the wavy white lines bordering the dark spots

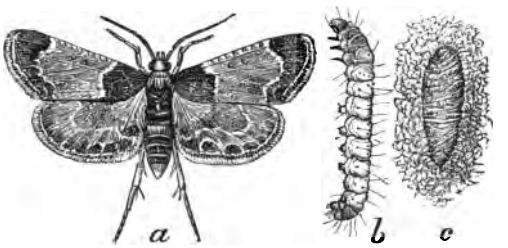


Fig. 19.—*Pyralis farinalis*: *a*, adult moth; *b*, larva; *c*, pupa in cocoon, twice natural size.—F. H. Chittenden, Division of Entomology, U. S. Department of Agriculture.

are characteristically striking. The larva makes tubes of silk, to which kernels of grain (if the worm is working in grain) adhere. (See Fig. 20.) Grain kept in dry and clean places is not likely to be affected.

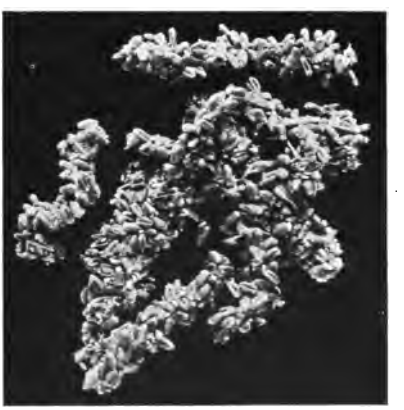


Fig. 20.—Silken tubes covered with wheat made by larvæ of *Pyralis farinalis*, half natural size.—Lugger.

The Confused Flour Beetle.

The accompanying figure (21) gives an excellent idea of this little pest, common enough in our flour mills. The beetle is dark brown, and practically omnivorous, attacking, according to Chittenden, flour, baking powder, red pepper, beans, peas, rice chaff, ginger, slippery elm, nuts and seeds of various kinds. We have

found it attacking dried insects in our cabinets. Like the other insects under discussion, a high temperature invites more rapid reproduction than when the temperature is low. It is said to attack and eat the larvæ of the Mediterranean Flour Moth.

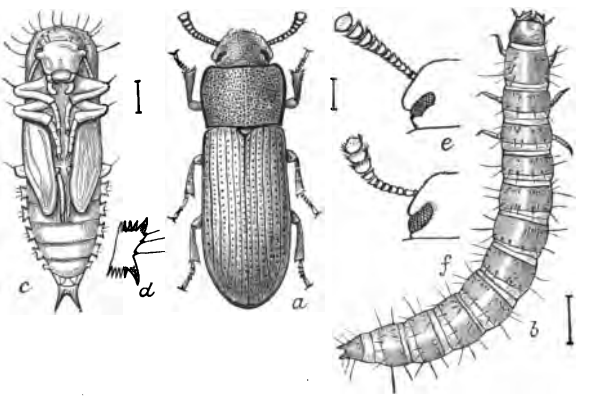


Fig. 21.—*Tribolium confusum*: *a*, beetle; *b*, larva; *c*, pupa, all enlarged; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle showing antenna; *f*, same of *T. ferrugineum*, all greatly enlarged.—F. H. Chittenden, Division of Entomology, U. S. Department of Agriculture.

The Slender-Horned Flour Beetle.

This insect is more common in the south, but deserves a place here. Indian corn is its special food. The beetle is brown, having

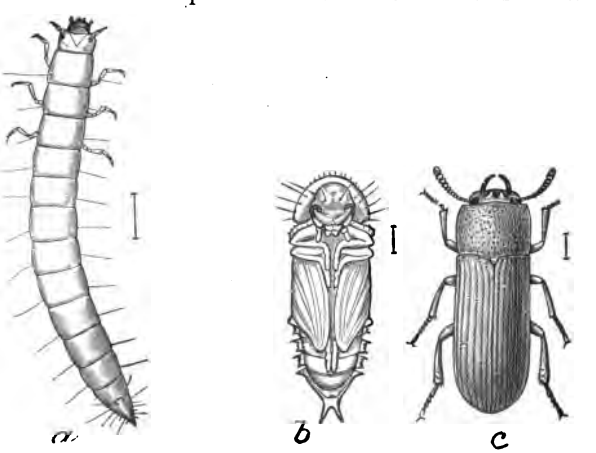


Fig. 22.—*Echocerus maxillosus*: *a*, larva; *b*, pupa; *c*, adult male, all enlarged.—F. H. Chittenden, Division of Entomology, U. S. Department of Agriculture.

on its head between its eyes, two small projections, readily seen in the illustration, Fig. 22. The Broad-horned Flour Beetle, and

the Small-eyed Flour Beetle should be added here; the first more abundant on the Pacific coast, the second abundant and injurious in bakeries, feed stores and mills.

The Yellow Meal Worm.

This, Fig. 23, is one of our more common pests in Indian meal and found in almost any mill products allowed to accumulate in neglected places. The "worm" is round, smooth, waxen as to its surface, and nearly an inch long and yellow. The adult beetles fly and are attracted to lights. Another allied form common in Am

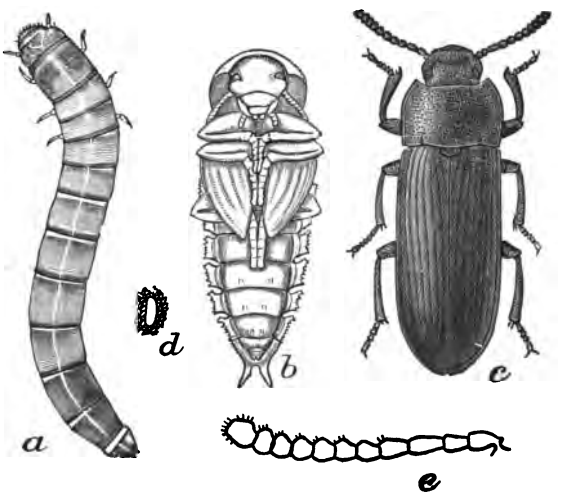


Fig. 23.—*Tenebrio molitor*: *a*, larva; *b*, pupa; *c*, female beetle; *d*, egg with surrounding case; *e*, antenna; *a*, *b*, *c*, *d*, about twice natural size; *e*, more enlarged.—Chittenden, Division of Entomology, U. S. Department of Agriculture.

ica, but probably introduced from Europe or Asia, is the Dark Meal Worm. The Yellow Meal Worm or its beetle, or both, are said to make holes in bolting cloth.

The Saw-Toothed Grain Beetle.

Very commonly, though wrongly, called "weevil." It gets its name from the little teeth on each side of the thorax. (See Fig. 24.) The beetle is reddish brown, and frequently very common in grain, also, according to Chittenden, feeding in flour, meal, dried fruits, seeds, breadstuffs, etc., and has been reported as having

been found in starch, tobacco and dried meats. One or two other allied beetles we pass over as not being abundant enough to merit discussion here.

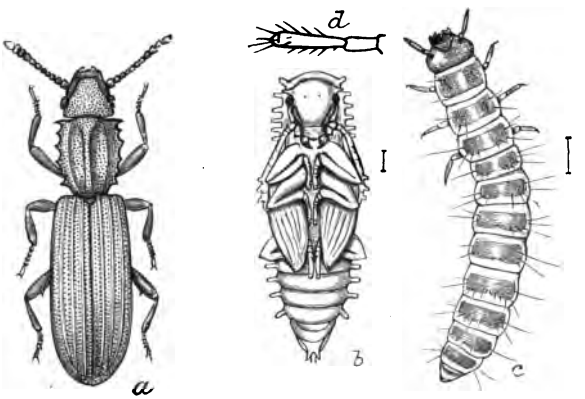


Fig. 24.—*Silvanus surinamensis*: *a*, adult beetle; *b*, pupa; *c*, larva, all enlarged; *d*, antenna of larva, still more enlarged.—Chittenden, Division of Entomology U. S. Department of Agriculture.

The Cadelle.

Sometimes called "The Bolting Cloth Beetle," living upon grain, is blackish, one-third of an inch long, and comes from a

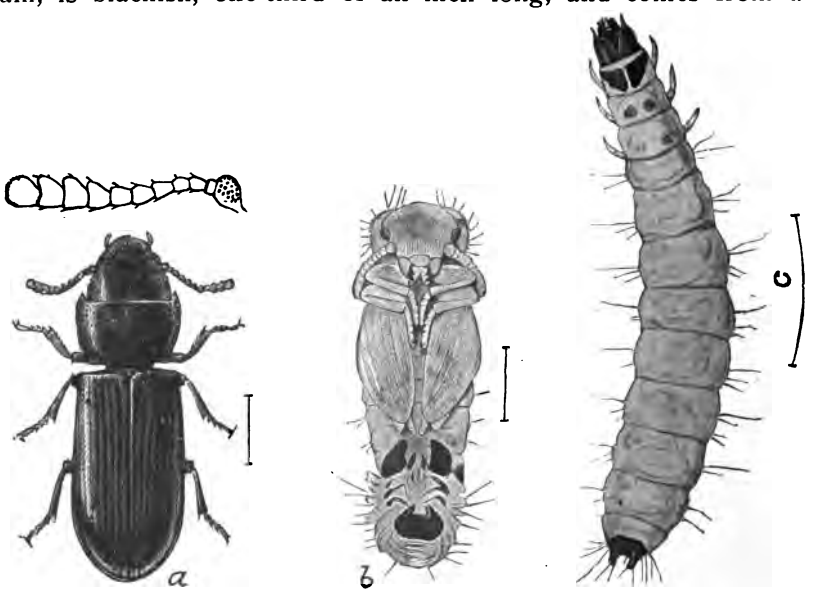


Fig. 25.—*Tenebroides mauritanicus*, Linn.: *a*, adult beetle with greatly enlarged antenna above; *b*, pupa; *c*, larva, all enlarged.—Chittenden, Division of Entomology, U. S. Department of Agriculture.

fleshy, whitish larva with a brown head. (See Fig. 25.) Both beetle and larva attack and eat other grain or flour insects which are met with. They are, therefore, not an unmixed evil.

ACKNOWLEDGMENTS.

The two successful methods of combating the Mediterranean Flour Moth in mills, *freezing* and *spraying with C. S.*$_2$, were told me in detail by practical millers who had resorted to these processes with happy results. To these parties my thanks are due and cheerfully given. I have not hesitated to use information contained in W. G. Johnson's article on "The Mediterranean Flour Moth (*Ephestia kuehniella,* Zeller) in Europe and America," published as an appendix to the 19th report of the State Entomologist of Illinois. From Farmers' Bulletin No. 45, United States Department of Agriculture, "Some Insects Injurious to Stored Grain," by F. H. Chittenden, statements were obtained bearing upon the habits and life histories of insects other than the Flour Moth found in flour mills and elevators. A number of Chittenden's illustrations have also been used.

The Booth Packing Company of Minneapolis very courteously allowed the use of their cold storage rooms in connection with experiments on the effects of different temperatures on the pest under discussion.

KEY TO INSECTS AFFECTING RASPBERRIES, BLACKBERRIES, CURRANTS, GOOSEBERRIES, STRAWBERRIES, GRAPES, MELONS, SQUASHES AND CUCUMBERS.

In our last report, a "Key for Orchardists and Nurserymen" is to be found, dealing with insects affecting the orchard and nursery. It has seemed desirable, in order to meet the many inquiries regarding pests from raisers of small fruits, to conclude the work begun last year by presenting the following key for the identification of insects attacking the plants given at the head of the paragraph. It is hoped that this key will be of value to market gardeners and others, and to further this, illustrations have been freely used and remedies given in each case, except where noted. As the method of controlling insect attack varies with varying

conditions, the gardener is urged to write to the Entomologist when in doubt; the latter will give all information in his power when called upon. The key has been based upon one compiled by Mr. Lochhead in the Thirty-fourth Annual Report of the Entomological Society of Ontario, but changes have been made in the shape of eliminations and additions to make it fit Minnesota conditions. The writer has seen fit to add melon, cucumber and squash insects, which are naturally of interest to market gardeners, and to give, at the conclusion of the key, for the benefit of the same class of agriculturists, a combined treatment for melon blight and for insects feeding upon the leaves of this plant.

INSECTS AFFECTING RASPBERRY AND BLACKBERRY.

A. *Attacking the Roots and Base of Canes:*

1. Large grub over two inches long, boring large tunnels in the woody portions of main root. The canes suddenly die.

GIANT ROOT BORER OR BROAD-NECKED PRIONUS.

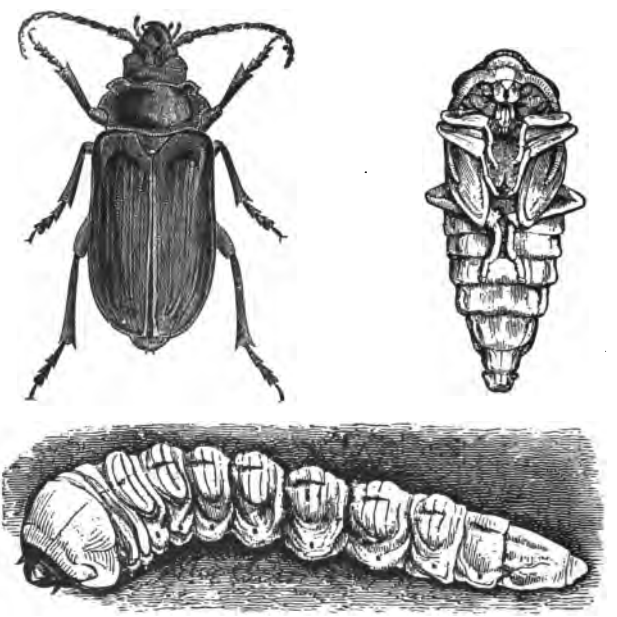


Fig. 26.—*Prionus laticollis,* Drury. After Riley.

REMEDY: Do not betray their presence until plant dies. When plant dies suddenly, or looks sickly from an unknown cause, examine roots carefully (and in case of raspberries and blackberries, the base of cane also), and if a borer is at work there, it should be sought for and killed.

2. Canes at base of main root girdled by a yellowish white caterpillar, in late summer and autumn.

BRAMBLE-CROWN BORER.

REMEDY: Canes dying or dead from an unknown cause should have their roots examined, and if this sixteen-legged grub is found it should be killed.

B. *Attacking the Canes:*

1. Longitudinal row of punctures on canes.

SNOWY TREE CRICKET.

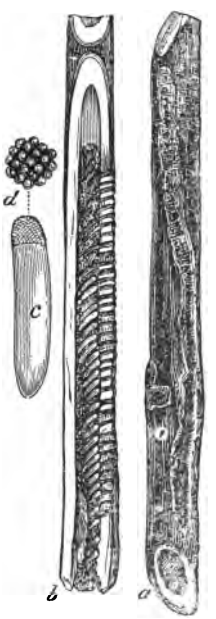


Fig. 28.

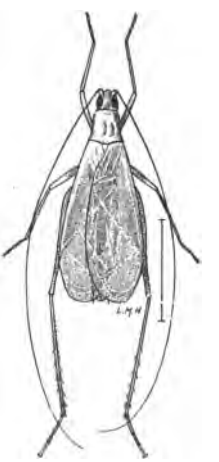


Fig. 29.

Fig. 28.—Eggs of *Œcanthus spec.*: *a*, twig showing punctures; *b*, twig split open to show eggs; *c*, a single egg; *d*, cap of egg, enlarged. After Riley.
Fig. 29.—*Œcanthus fasiatus*, male. Resembling Snowy Tree Cricket. Lugger.

REMEDY: Cut off the portions containing the rows of punctures, and burn. This is best done in early spring or late fall. Shaking the bushes will sometimes dislodge the full-grown insects.

2. Tips of shoots of raspberry wilting; two rows of punctures one inch apart at base of wilted portion, with a small hole between. Canes are burrowed to the base before autumn.

RASPBERRY CANE BORER.

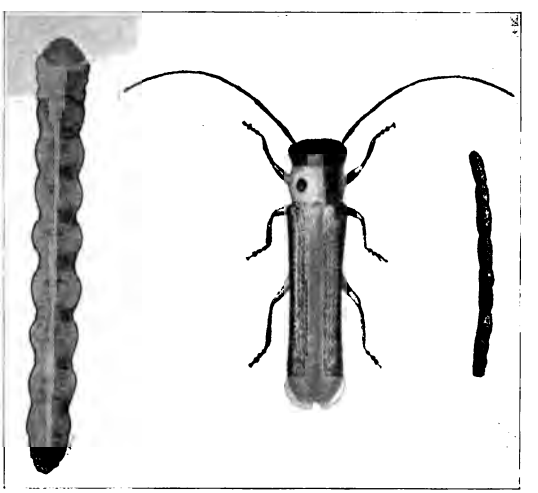


Fig. 30.—*Oberea bimaculata,* Oliv.; adult, larva and castings. After Webster.

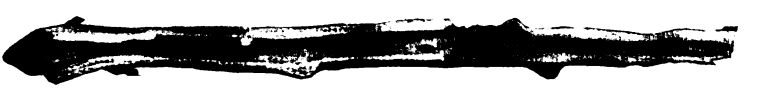


Fig. 30½.—Burrow of *Oberea bimaculata,* Oliv.

REMEDY: Look over bushes occasionally in June and early July and remove all withered tops. Be sure to cut low enough to catch the borer, and destroy the portion cut off, with contained grub.

3. Swellings on canes of raspberry and blackberry.

RED-NECKED CANE BORER.

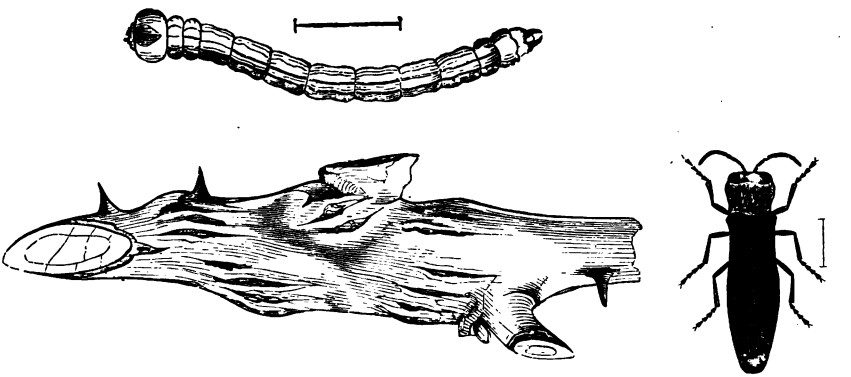


Fig. 31.—*Agrilus ruficollis,* Fab. Gall, beetle and larva. After Riley.

REMEDY: Cut out the swellings in spring and burn.

4. A brownish, purplish or pale worm in new canes, causing tips to droop. Look for opening of burrow in cane.

STALK BORER.

Fig. 32.—*Hydræcia* (*Gortyna*) *nitela,* Gu. From Riley.

REMEDY: Cut off affected top below burrow. Be sure to remove the worm. If the center shows evidences of his boring below the hole, work down until you find him.

C. *Injuring the Buds:*

1. A small snout-beetle, puncturing the flower stem close to the buds, and also the buds.

STRAWBERRY WEEVIL.

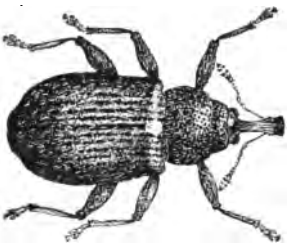


Fig. 33.—*Anthonomus signatus.* Original.

REMEDY: More injurious to strawberry than raspberry. Spraying with Paris green and Bordeaux (one pound of Paris green to every 100 gallons of Bordeaux) would probably be helpful.

2. A small yellowish beetle eating the flower buds, which fail to open, or wither.

PALE BROWN BYTURUS.

Fig. 34.—*Byturus unicolor,* Say. After Saunders.

REMEDY: Hand picking could be resorted to if it should ever become abundant.

3. A small brownish caterpillar eating the opening buds.

BUD MOTH.

Fig. 35.—*Tmetocera ocellana,* Schiff. From Saunders.

REMEDY: If any treatment is necessary, spray with Paris green, one pound to 150 gallons of water, just before the buds break.

D. *Attacking the Leaves:*

1. Insect sucking the sap of young growing parts, and arresting their development.

TARNISHED PLANT BUG.

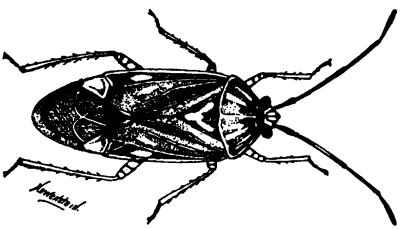


Fig. 36.—*Lygus pratensis,* Linn. Lugger.

REMEDY: Allow no rubbish to lie over winter under the vines or near them, since such cases afford a secure winter retreat for the bugs.

2. Hairy, brownish caterpillars, feeding singly on leaves.

RASPBERRY DAGGER MOTH.

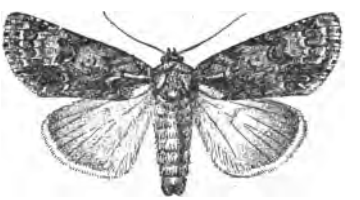


Fig. 37.—*Acronycta impressa,* Walk; moth. Lugger.

REMEDY: Paris green sprays kill all leaf-eating insects.

3. A smooth pale yellow caterpillar, about 1½ inches long.

CHAIN-DOTTED GEOMETER.

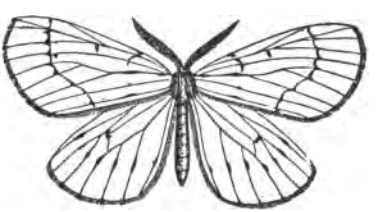


Fig. 38.—*Caterva catenaria,* Cram. After Packard.

REMEDY: Hellebore, which, though poisonous to insects, is harmless as far as man is concerned, could be dusted over the leaves for this or any other leaf-eating worm.

4. Rolling tender leaves and feeding within, a greenish or yellowish worm ¾ of an inch long.

OBLIQUE-BANDED LEAF ROLLER.

Fig. 39.—*Cacœcia rosaceana.* Lugger.

REMEDY: Hand picking early in season and sprays will keep in check if remedy is necessary.

5. A yellowish brown beetle ⅓ of an inch long, feeding upon the leaves.

LIGHT-LOVING ANOMALA.

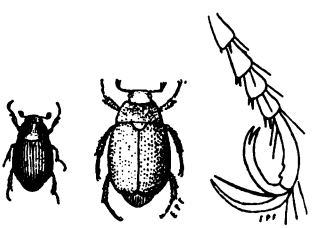


Fig. 40.—*Anomala marginata,* Fab.: *A, lucicola,* Fab., and enlarged tarsal claws. After Lintner.

REMEDY: Dangerous when in large numbers only. Spray leaves with Paris green (one pound in 150 gallons of water) or use hellebore.

E. *Attacking the Fruit:*

1. A looping worm feeding on fruit of raspberry and blackberry.

RASPBERRY GEOMETER.

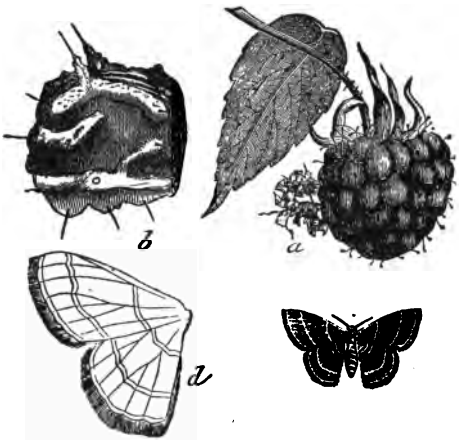


Fig. 41.—*Synchlora glaucaria*, Gu.: *a*, caterpillar; *b*, one segment of same; *d*, wings enlarged. After Riley.

REMEDY: Hand picking is only remedy which can be suggested.

2. Laying eggs on fruit, causing "buggy" taste, a black bug.

FLEA-LIKE NEGRO BUG.

Fig. 42.—The Flea-like Negro Bug. Original.

REMEDY: No remedy called for.

3. A small white grub found inside the raspberry when picked.

RASPBERRY FRUIT-WORM.

See Fig. 34.

REMEDY: Not common in Minnesota.

The following also attack the raspberry and blackberry. Isabella tiger moth (young shoots); the Hickory and Checkered Tussock Moth; the Waved Lagoa; the Saddle-backed Caterpillar; the Unicorn Prominent; the Smeared Dagger Moth; the Raspberry Plumed Moth; the Raspberry Leaf-roller; the Blackberry flea louse; the Long-horned Prominent; the Eye-spotted Bud Moth; the Apple-leaf Miner; the Blackberry-leaf Miner, and others.

CURRANT AND GOOSEBERRY INSECTS.

A. *Attacking the Canes:*

1. Center of canes tunneled by a white caterpillar.

IMPORTED CURRANT BORER.

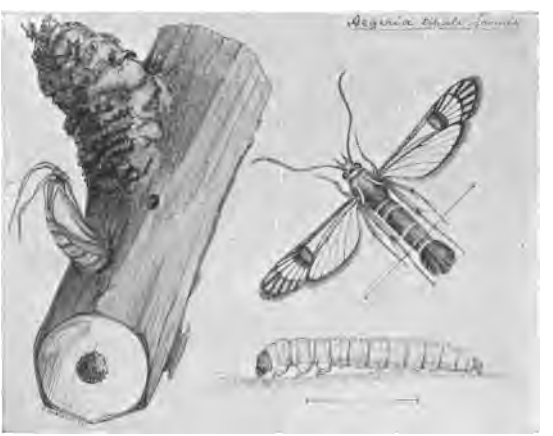


Fig. 43.—*Sesia tipuliformis,* Linn. Lugger.

REMEDY: Prune the sickly looking canes, cutting them off below the lowest part of the tunnel made by the worm.

2. Small, flat, circular scales, black or gray, with a depressed ring about a central nipple in black forms.

SAN JOSE SCALE.

(Not known to be in Minnesota at this date.)

Fig. 44.—San Jose Scale on bark of apple. Garman.

3. Oval, hemispherical scales.

CURRANT LECANIUM.

REMEDY: Not common. See Remedies Nos. 28, 31 and 35, on pages 110, 113, 114, Bulletin 84, from this department.

B. *Attacking the Leaves:*

1. Larvæ, 20-legged, dull white when young, then greenish, with black spots, finally greenish yellow, eating holes in the leaves in early spring.

IMPORTED CURRANT WORM.

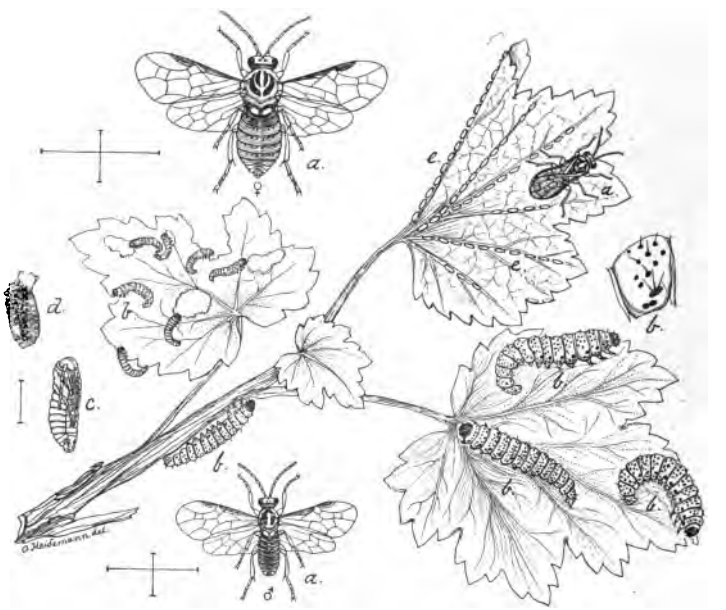


Fig. 45.—*Nematus ventricosus,* Klug: *a,* male and female saw flies; *b,* larvæ of different sizes; *d,* cocoon; *e,* eggs. Lugger.

REMEDY: Spray or sprinkle bushes with one tablespoonful of Paris green in pail of water, keeping liquid constantly stirred. This is to be applied only when fruit is green. When later treatment is necessary, use hellebore dry when leaves are moist, or in water, one ounce to each pailful.

2. Leaves paling, through attacks of green sucking insects on under side.

LEAF HOPPER.

Fig. 46.—Currant leaf infested with *Empoasca albopicta,* Walsh. Lugger.

REMEDY: Currants badly infested before fruit is ready to pick should be treated with a fine spray of kerosene emulsion, throwing as much as possible on under side of leaves.

3. Leaves curled, blistered, and with a reddish appearance on upper surface, caused by yellowish plant lice.

CURRANT PLANT LOUSE.

REMEDY: Same as above.

4. A small brownish bug, sucking sap from leaves.

TARNISHED PLANT BUG.

See Fig. 36.

REMEDY: Allow no rubbish to collect under which the bugs may hibernate. Possibly a kerosene emulsion spray would kill many young.

5. Leaves turning brown and dying.

FOUR-LINED LEAF BUG.

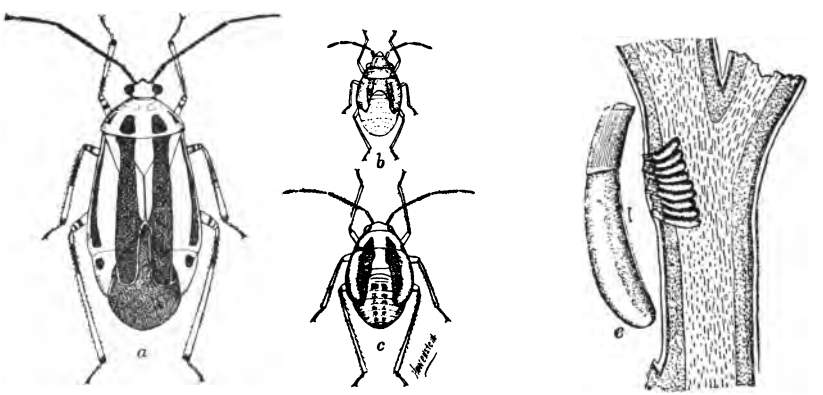


Fig. 47.—*Pœcilocapsus lineatus*, Fab.: *a*, adult; *b*, *c*, immature. Lugger. Eggs after Slingerland.

REMEDY: If troublesome, use kerosene emulsion (one part emulsion to eight of water) several times during May and June.

6. Measuring worm, feeding on leaves of gooseberry and black currant.

CURRANT SPAN-WORM.

REMEDY: All leaf-eating Caterpillars may be killed with Paris green sprays or hellebore. This worm has a habit of lowering itself, and hanging by a thread when disturbed, hence strike the bush affected, then pass a stick all around under it, thus catching the threads on which the Caterpillars are hanging; lift these out from under the bush and step on them.

7. Brown or yellow spiny caterpillar, feeding on leaves of currant and gooseberry, two-brooded in Minnesota.

SPINY CURRANT CATERPILLAR.

Fig. 48.—*Grapta comma*, Harr., showing two butterflies, caterpillar and empty chrysalis. Lugger.

REMEDY: Use Paris green sprays or hellebore if remedy is necessary.

8. Feeding on leaves during summer, a yellowish (bluish white when young) hairy caterpillar.

COMMON YELLOW BEAR.

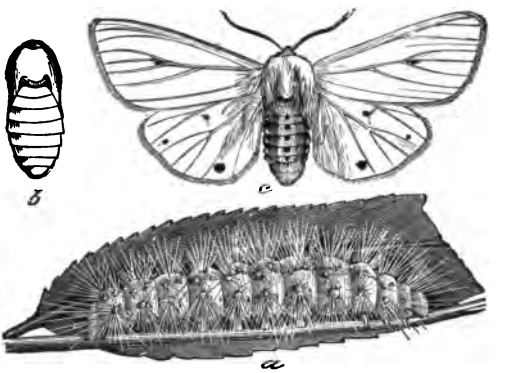


Fig. 49.—*Spilosoma virginica*, Fab.: *a*, caterpillar; *b*, pupa; *c*, adult. After Riley.

REMEDY: Same as preceding; also hand picking.

C. *Attacking the Fruit:*

1. Greyish or greenish caterpillar boring into young fruit, and eating out its contents. Sometimes fasten berries together.

GOOSEBERRY FRUIT WORM.

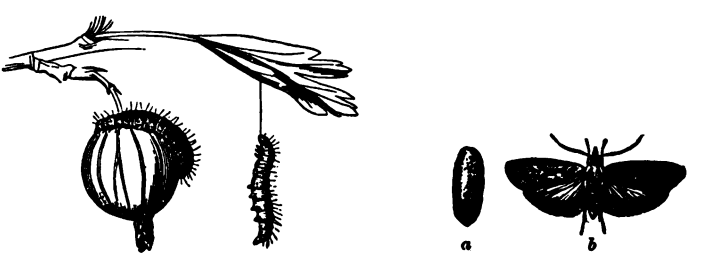


Fig. 50.—*Zophodia grossulariæ*, Pack.: *a*, cocoon; *b*, moth. After Saunders.

REMEDY: Let chickens run among the bushes after fruit is picked. Remove and burn all rubbish in fall.

2. A pale or greenish caterpillar ½ inch long, injuring fruit of currant. Not common in Minnesota.

CURRANT FRUIT WORM.

Fig. 51.—*Eupitheci interruptofasciata,* Pack.

3. Small grub feeding in fruit of currant and gooseberry, causing it to turn red prematurely.

CURRANT FLY.

REMEDY: Same as for Gooseberry Fruit Worm.

The following insects also work on currants, and to some extent on gooseberries:

American Currant Borer; Native Currant Borer; Saddle-backed Caterpillar; Io Emperor Moth; Currant Endropia; Currant Angerona; Pepper and Salt Currant Moth; Oblique-banded Leaf Roller, etc.

GRAPE INSECTS.

A. *Attacking the Roots:*

1. Producing little irregular spherical galls on rootlets and larger roots, causing death. Have not met with it in Minnesota.

GRAPE-VINE PHYLLOXERA.

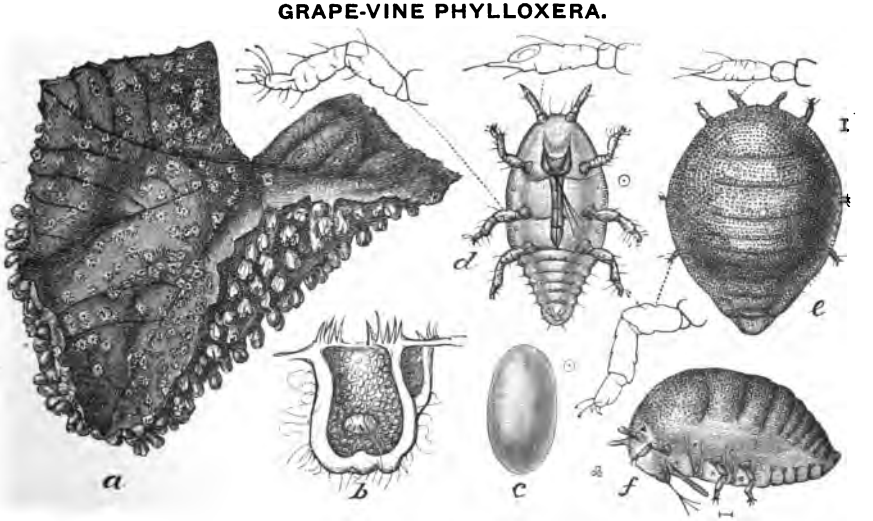


Fig. 52.—*Phylloxera vastatrix,* Plach.: *a,* leaf with galls; *b,* section of galls showing mother louse at center with young clustered about; *c,* egg; *d,* larva; *e,* adult female; *f,* same from side—a, natural size, rest much enlarged. From Marlatt, Dep. of Agriculture.

2. Large borer, cutting a tube through the root near the surface.

BROAD-NECKED PRIONUS.

See Fig. 26.

REMEDY: See same insect under "Insects Affecting Raspberry and Blackberry," page 48.

3. Grub eating the bark of both the large and small roots. Beetles eating holes in leaves.

GRAPE-VINE FIDIA.

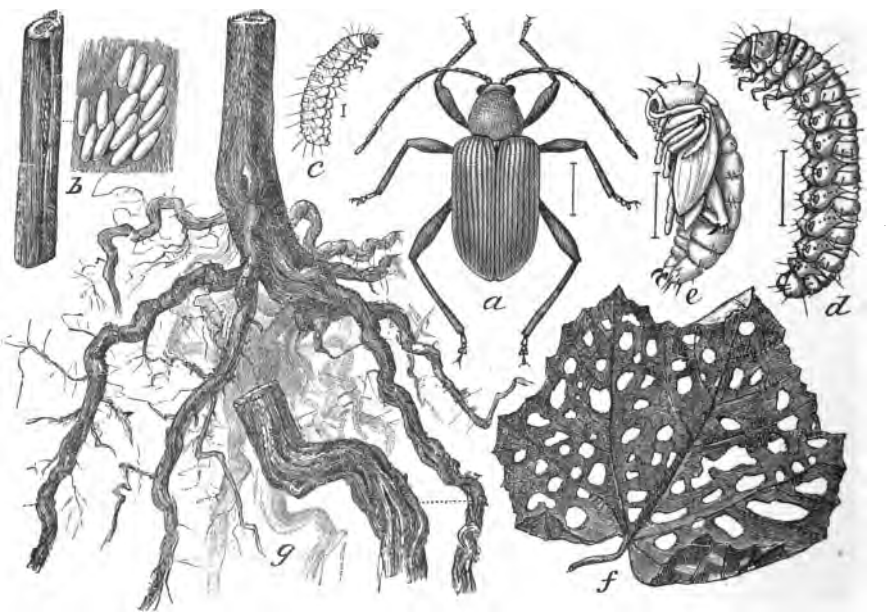


Fig. 53.—*Fidia viticida,* Walsh. From Marlatt, U. S. Dep. of Agriculture.

REMEDY: The adult beetle can be jarred from the leaves into sheets placed beneath the grapevines in June and July.

4. A yellowish-white worm working in the roots.

GRAPE-VINE ROOT BORER.

(Rare in Minnesota.)

Fig. 54.—*Sciapteron polistiformis,* Harr.: Larva, cocoon, male and female. After Glover, U. S. Dep. of Agriculture.

B. *Attacking the Branches:*

1. Young shoots suddenly break off or droop in spring; a small hole just above the base of the shoot leads into a burrow.

APPLE-TWIG BORER.

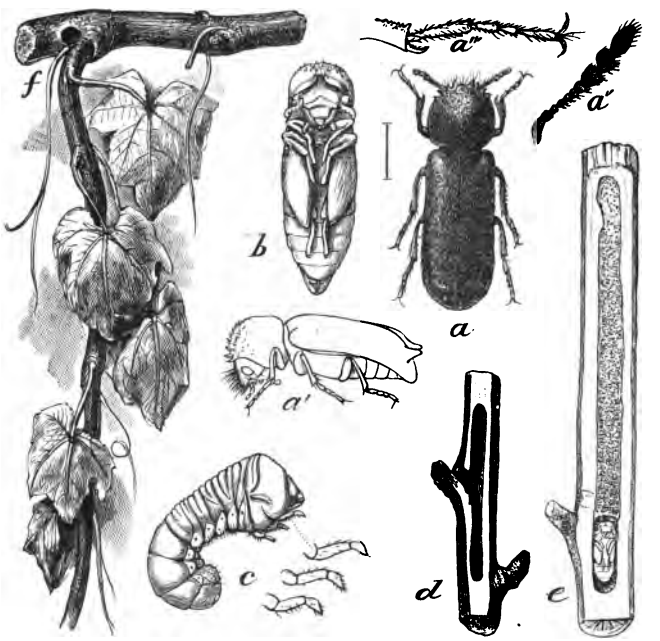


Fig. 55.—*Amphicerus bicaudatus,* Say. From Marlatt, U. S. Dep. of Agriculture.

REMEDY: Removing and burning twigs with burrows of this Beetle will check the ravages somewhat.

2. Canes show roughened longitudinal rows of perforations.

SNOWY TREE CRICKET.

See Fig. 29.

REMEDY: See under "Insects Affecting Raspberry and Blackberry," page 49.

3. Canes exhibiting white, cottony masses attached to a reddish brown scale.

COTTONY MAPLE SCALE.

REMEDY: Not abundant on grape. Can be easily scraped off, or touched with a feather dipped in kerosene.

4. Canes exhibiting white frothy masses which resemble spittle.

SPITTLE INSECT.

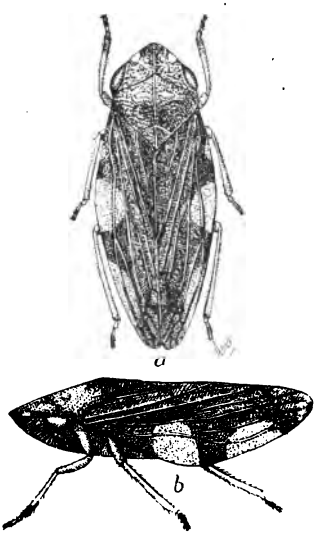


Fig. 56.—*Aphrophora 4-notata*, Say.: *a*, from above; *b*, from side. Lugger.

REMEDY: If sufficiently abundant to be injurious, can be crushed by the hand.

C. *Attacking the Leaves:*

1. Leaves riddled with irregular holes about midsummer, by a little beetle.

GRAPE-VINE FIDIA.

REMEDY: See page 64.

(Another leaf beetle, *Adoxus obscurus*, is sometimes troublesome in Minnesota.)

2. A yellowish-brown beetle ⅓ of an inch long, feeding on leaves.

LIGHT-LOVING ANOMALA.

REMEDY: See page 54, under "Insects Affecting Raspberry and Blackberry."

3. Boring into buds in spring, also eating small holes in expanding leaves, small shining blue beetle.

GRAPE-VINE FLEA BEETLE.

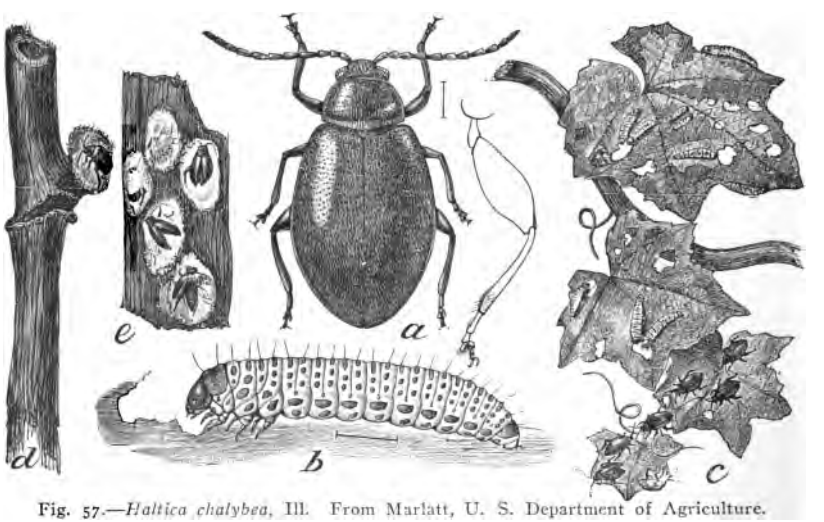


Fig. 57.—*Haltica chalybea*, Ill. From Marlatt, U. S. Department of Agriculture.

REMEDY: The winter is passed under leaves beneath the vine, or in the ground near the roots. Therefore, allow chickens to scratch among the vines in fall after grapes are picked, and later remove and burn all rubbish, and scatter some air slaked lime or unleached ashes on the earth. It is claimed that on chilly mornings these Beetles are not active, and can be jarred from the leaves.

4. Long legged, brownish beetles eating the blossom, leaves and fruit.

ROSE CHAFER.

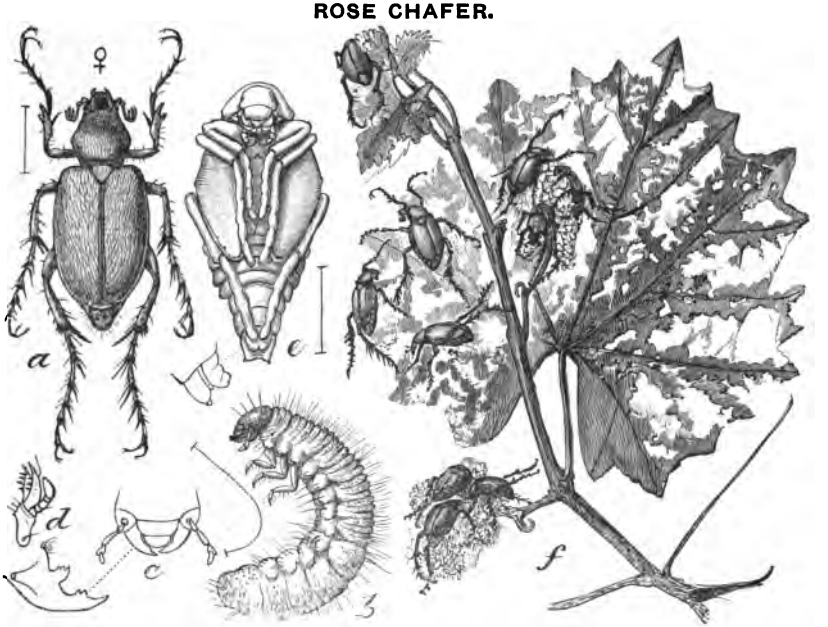


Fig. 58.—*Macrodactylus subspinosus*, Fab. From Marlatt, Division of Entomology, U. S. Department of Agriculture.

REMEDY: Can be jarred on sheets in the cool of the morning.

5. Greenish caterpillar feeding within a folded leaf and skeletonizing it, about midsummer.

GRAPE-LEAF FOLDER.

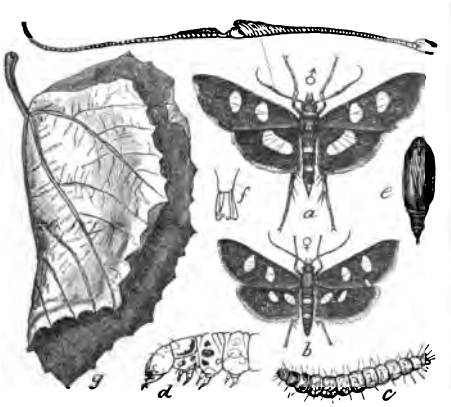


Fig. 59.

Fig. 60.

Fig. 59.—*Desmia maculalis*, Westw.: *a*, male moth; *b*, female; *c*, larva; *d*, head and thoracic segments of same enlarged; *e*, pupa; *f*, tip of same enlarged; *g*, leaf folded by larva. From Marlatt, Dep. of Agriculture.

Fig. 60.—Grape leaf folded by this insect. Original.

REMEDY: Caterpillar can be destroyed by crushing the rolled leaf. The writer has picked the rolled leaves from his own vines and burned them or crushed them, being careful not to let the worm slip out of the leaf.

6. Leaves blotched and scorched, finally curling up and falling, by little jumping insects.

GRAPE THRIP OR LEAF HOPPER.

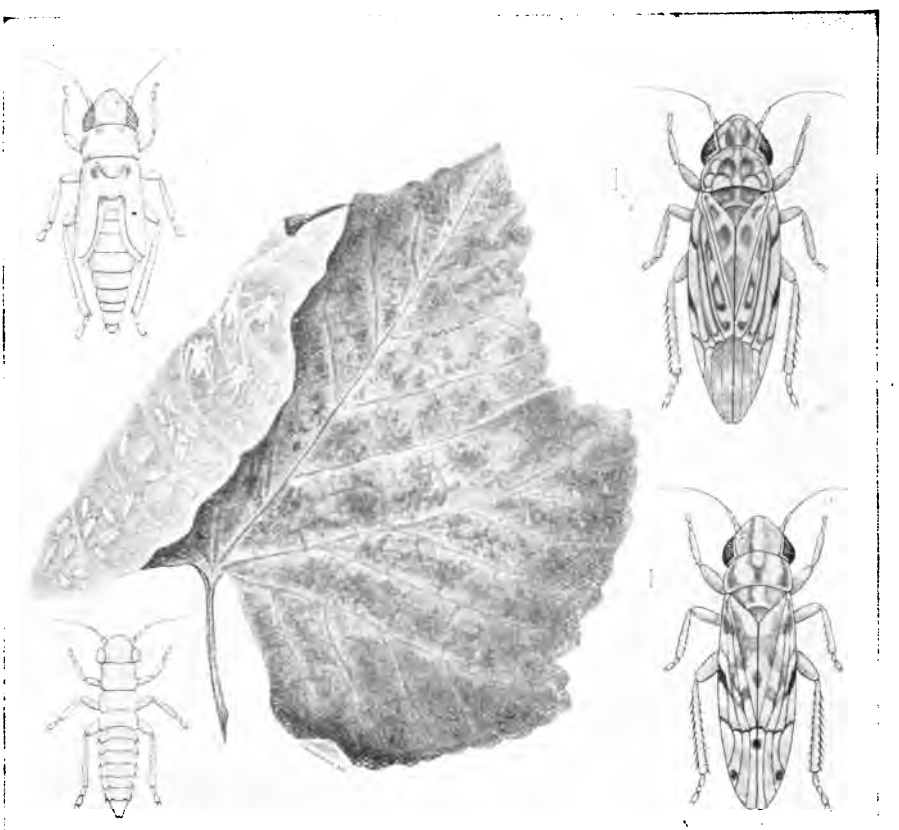


Fig. 61.—Grape vine leaf infested with *Typhlocyba* species, Lugger.

REMEDY: Remove all rubbish in the fall, and disturb the ground by raking.

7. Large greenish caterpillar, with a pale yellow stripe down each side, and a horn near tail.

GRAPE-VINE SPHINX.

Fig. 62.—*Ampelophaga myron*, Cram., caterpillar. After Riley.

REMEDY: Hand picking is best remedy. Small parasites help us in combating this pest.

8. Black beetle eating the tissues on the upper surfaces of the leaves, and discoloring them.

RED-HEADED SYSTENA.

REMEDY: Paris green sprays would be effective.

9. Large reddish yellow beetle, with six black spots on wing-cover, eating holes in leaves.

SPOTTED PELIDNOTA.

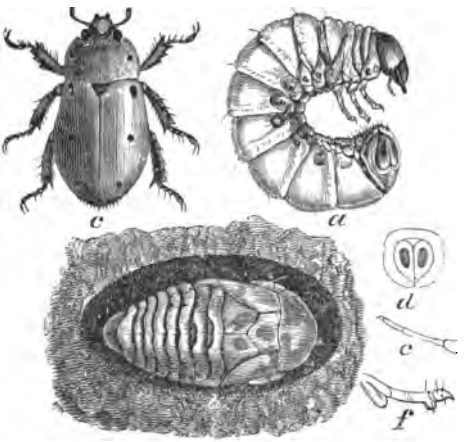


Fig. 63.—*Pelidnota punctata*, Linn. After Riley.

REMEDY: Not common in Minnesota. Hand picking if necessary.

10. A purplish or orange colored worm with dark markings, feeding on leaf of grape and woodbine.

EIGHT-SPOTTED FORESTER.

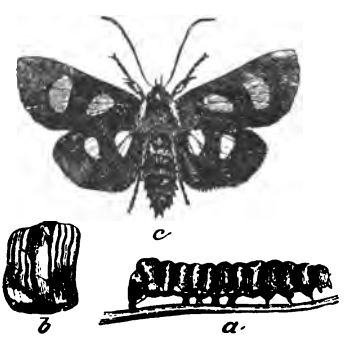


Fig. 64.—*Alypia octomaculata*, Hbn.: *a*, caterpillar; *b*, one segment of the same; *c*, adult. After Riley.

REMEDY: Hand picking, or Paris green or hellebore when necessary.

D. *Attacking the Fruit:*

1. Ripening fruit discolored, and burrowed by a whitish caterpillar.

GRAPE BERRY MOTH.

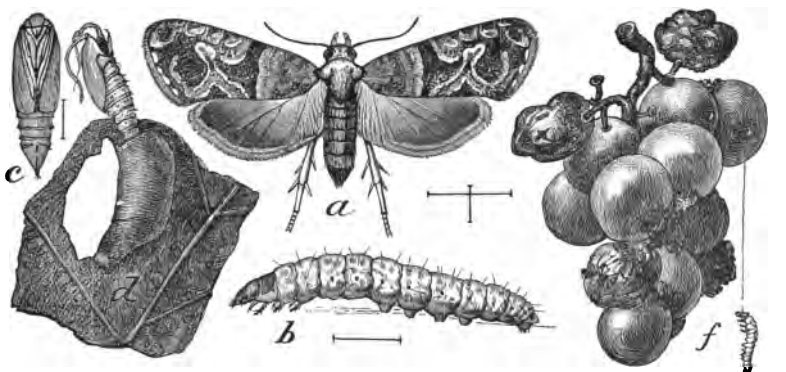


Fig. 65.—*Polychrosis viteana*, Clem.: *a*, moth; *b*, larva; *c*, pupa; *d*, case with empty pupa, all enlarged; *f*, grapes with worm natural size. From Marlatt, Dep. of Agriculture.

REMEDY: Rake up and destroy the fallen leaves and rubbish under the vines in the fall. Early gathering and shipping are recommended. All fallen fruit should be destroyed. Bagging grapes as soon as fruit sets would be effective, but not practical on a large scale. A new parasite (*Thymaris slingerlandana*, Ashm.) has recently been bred from this pest.

2. Eating holes in ripe fruit, beetle large, yellowish, hairy.

BUMBLE FLOWER BEETLE.

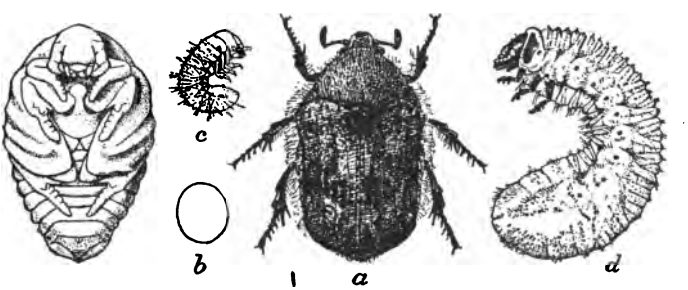


Fig. 66.—*Euphoria inda*, Linn. From Chittenden, U. S. Department of Agriculture.

REMEDY: Hand picking.

3. Eating holes in young fruit, a long-legged beetle.

ROSE CHAFER.

See Fig. 58.

REMEDY: See page 69.

4. Fruit discolored on one side by the presence within of a small yellowish-white grub.

GRAPE CURCULIO.

(Not common in Minnesota.)

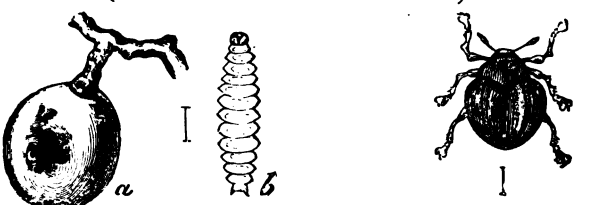


Fig. 67.—*Craponius inæqualis*, Say. After Riley.

The following insects also attack the Grape: Saddle-backed Caterpillar, various tree hoppers not mentioned above; Spotted Vine Chafer; many Sphinx moths; Hog Caterpillar; Red-Shouldered Sinoxylona; False Chinch Bug; American Procris; Smeared Dagger Moth; Gartered Grape Plume; Sulphur Colored Tortrix, and others.

STRAWBERRY INSECTS.

A. *Attacking the Roots:*

1. A pinkish caterpillar boring irregular channels through the crown and larger roots, causing them to wither and die.

STRAWBERRY ROOT BORER.

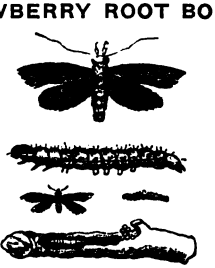


Fig. 68.—*Anarsia lineatella*, Zell. After Saunders.

REMEDY: No practical remedy. Badly infested plant should be dug up, and a new planting made.

2. A white grub boring downward from the crown.

STRAWBERRY CROWN BORER.

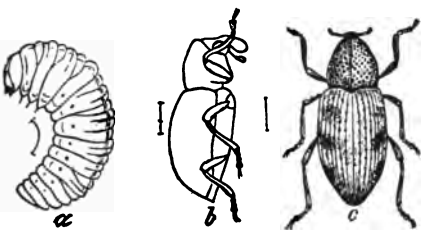


Fig. 69.—*Tyloderma fragariæ*, Ril. After Riley.

REMEDY: Old beds more likely to be infested than new beds. Dig up and burn plants after fruiting season.

3. Eating out the crown and roots, a dark brown snout beetle or its whitish grub. Quite destructive, at times, in this state.

PITCHY-LEGGED OTIORHYNCUS.

Fig. 70.—*Otiorhynchus ovatus*, Linn.

REMEDY: No remedy known beyond the digging up and destroying of old beds when infested.

4. A large white grub eating the roots.

MAY BEETLE.

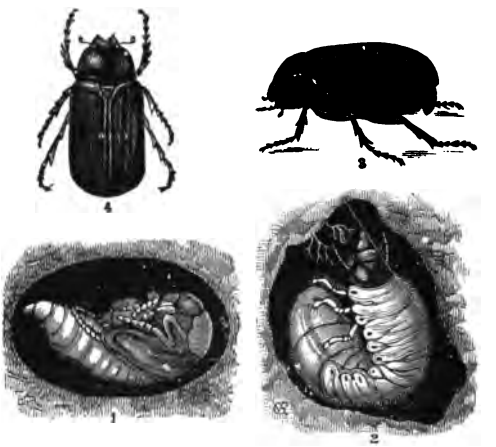


Fig. 71.—*Lachnosterna fusca*, Frœhl. From Riley.

REMEDY: Grubs eaten by fowls. Crows are fond of them. They are attacked by disease.

5. A hard yellowish or brownish worm eating the root.

WIRE WORM.

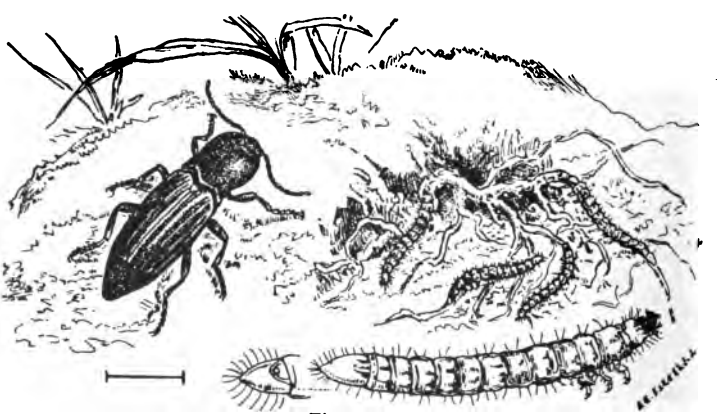


Fig. 72.

REMEDY: Plant strawberries only in land which has been in cultivation some time. Wire worms may be trapped or poisoned. See page 172.

B. *Attacking the Leaves:*

1. Brownish caterpillars in June and August rolling the leaves into cases, and fastening them with silk.

LEAF ROLLER.

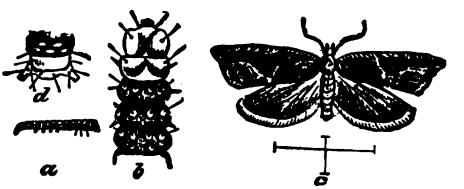


Fig. 73.—*Phoxopteris comptana,* Froel. After Saunders.

REMEDY: If bad, sprinkle with hellebore and water, or gather and burn infested leaves. See page 54.

2. Young plants gnawed off at the surface.

CUT WORMS.

Fig. 74.—*Agrotis ypsilon,* Rott. After Riley.

REMEDY: Cut worms may be trapped or poisoned. See page 171.

3. Small, pale spotted, active beetles riddle the leaves with holes in June. The young beetle in the grub form attacks the root.

SPOTTED PARIA.

REMEDY: Use hellebore.

4. A small blackish snout beetle puncturing stems and buds of staminate varieties.

STRAWBERRY WEEVIL.

See Fig. 33.

REMEDY: No really good remedy. The burning over of old fields after crop is gathered has been suggested. Plant chiefly pistillate varieties, using only occasional rows of staminate plants. Write to the experiment station if radical measures seem necessary.

5. A small, active, jumping striped beetle, eating holes in the leaves.

STRIPED FLEA BEETLE.

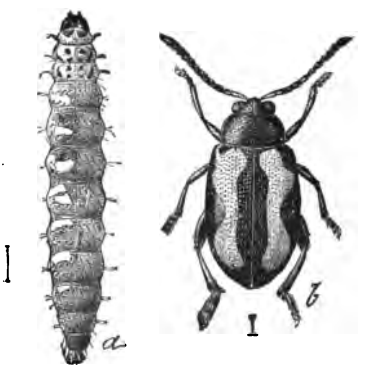


Fig. 75.—*Phyllotreta vittata,* Fab. From Riley, U. S. Department of Agriculture.

REMEDY: Same as for Spotted Paria.

6. A brownish bug, ⅓ of an inch long, sucking the sap from buds and leaves, causing them to wither.

TARNISHED PLANT BUG.

REMEDY: See page 53.

C. *Attacking the Fruit:*

1. A caterpillar feeding on the berry.

STALK BORER.

REMEDY: See page 51.

2. A minute black bug, producing a "buggy" odor when eaten with berry.

FLEA-LIKE NEGRO BUG.

See Fig. 42.

REMEDY: No remedy called for.

3. A black beetle nearly an inch long, eating the berry.

HARPALUS PENNSYLVANICUS.

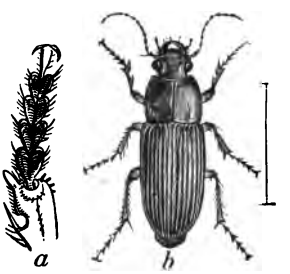


Fig. 76.—*Harpalus pennsylvanicus*, De G.: *a*, anterior tarsus and part of tibia showing notch; *b*, beetle. After Riley.

REMEDY: Bran mixed with water sweetened with molasses, and poisoned with Paris green, is said to be fairly effective. It should be placed at intervals through the strawberry patch, each portion covered with a piece of shingle or board. Pick beetles and destroy them if necessary. Traps in the shape of boards, etc., are good. Write for further particulars if troubled with this pest. See also Seventh Annual Report of Entomologist (Bulletin 77), page 39.

The following insects also attack the Strawberry: Wavy-striped Flea Beetle, Imbricated Snout Beetle, Grape-vine Caterpillar, Thread-bearing Span Worm, Rusty Brown Tortrix, Sulphur-colored Tortrix, etc.

INSECTS AFFECTING MELONS, SQUASHES AND CUCUMBERS.

A. *Attacking the Leaf:*

1. Small green bugs on under side of melon leaves.

MELON LOUSE.

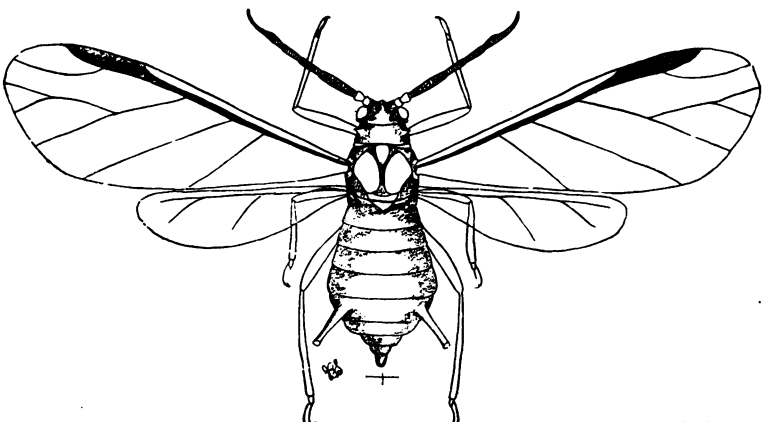


Fig. 77.—*Aphis cucumeris*, Forbes. Winged viviparous female. After Smith.

REMEDY: If melon patch is very small, spray under side of leaves with kerosene emulsion (1-12), or dust under side of leaves with pyrethrum. Whether the patch be large or small, destroy all old vines and rubbish on melon patch, and plant some crop other than melons or cucumbers there the following season. Frequently the attacks of this louse are not of long duration. Parasites kill many.

2. A brownish bug about ¾ inch long on leaf.

TRUE SQUASH BUG.

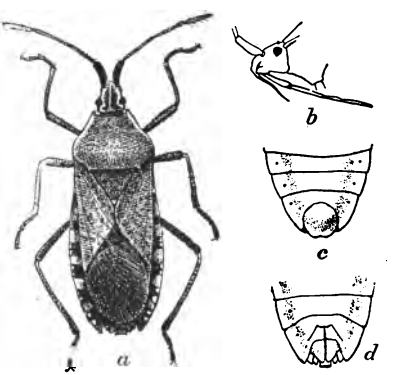


Fig. 78.—*Anasa tristis*, De G.: *a*, mature female; *b*, side view of head, showing beak; *c*, abdominal segments of male; *d*, same of female;—*a*, twice natural size; *b*, *c*, *d*, slightly more enlarged. After Chittenden, Div. of Entomology, Dep. of Agriculture.

REMEDIES: Protection of young plants by coverings. 2. Planting an excess of seed in order to distribute the attack. 3. Hand picking early in the morning. 4. Hand picking the large yellowish brown eggs, which can be found without much difficulty on the under side of the leaves. 5. Strewing some repellant on soil close to plant, such as lime, or gypsum, or sand saturated with kerosene or turpentine. This is of questionable efficacy. 6. As this insect hibernates in rubbish on field, it is of the utmost importance that all vines should be destroyed immediately after gathering the crop, thus killing the immature bugs, which are still on the vines. One should burn in the fall all rubbish likely to afford winter quarters for this pest. 7. It is claimed that this bug will not touch cucumbers if there are squashes in the neighborhood; that it prefers squashes to pumpkins and pumpkins to cucumbers and melons; hence, if one wished to raise cucumbers or melons, he might (if the above statements are correct) plant squashes or pumpkins near them as a catch crop.

3. A yellow and black striped beetle, ⅓ of an inch long, feeding on leaf and blossom; wrongly called "Squash Bug."

STRIPED CUCUMBER BEETLE.

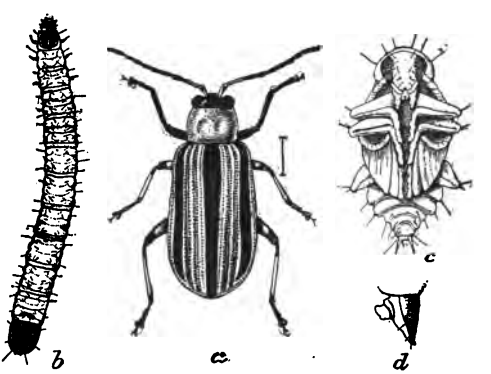


Fig. 79.—*Diabrotica vittata,* Fab. From Chittenden, U. S. Department of Agriculture.

REMEDY: Paris green may be dusted dry on the plants, mixed with slaked lime or cheap flour, about one part of Paris green to 50 or 60 parts of flour or lime. At least one party (Forrest Henry) has obtained relief by dusting the pure Paris green sparingly upon the plants, the plants not having been burned thereby. Tobacco dust scattered about the young plants is said to keep the Beetle away for quite a while. One should always burn the plants in the fall immediately after gathering the crop, thereby killing a large number of insects as well as destroying probably some eggs which have not hatched, and thus lessening the Beetle crop for next year. Planting a much larger number of seeds than are actually needed is also practiced.

4. A greenish yellow beetle, same size as above, with 12 black spots, feeding on leaf of plant.

TWELVE-SPOTTED DIABROTICA.

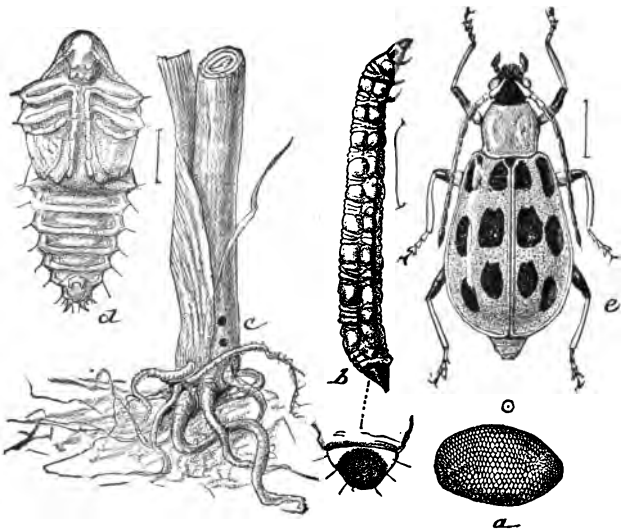


Fig. 80.—*Diabrotica 12 punctata,* Oliv. After Riley, U. S. Dep. of Agriculture.

REMEDY: Same remedies as for Striped Cucumber Beetle.

5. A black shining beetle, which jumps like a flea, found on melons and cucumbers.

CUCUMBER FLEA BEETLE.

Fig. 81.—*Epitrix cucumeris,* Harr. From Chittenden, U. S. Dep. of Agriculture.

REMEDY: Really more troublesome to leaves of apple trees than to cucumbers. Would be easily kept in check by treatment for two preceding pests.

The Melon Caterpillar attacks melons, and the Neat Cucumber Moth or Pickle Worm attacks fruit of cucumber, but we have not met with these in this state.

CONTROL OF MELON BLIGHT AND LEAF-EATING MELON INSECTS.

That this troublesome fungus disease, which works on melons and cucumbers, can be combated, if treatment is begun early enough, has been practically demonstrated. Bordeaux mixture properly made and properly applied has been found successful. It must be borne in mind, however, that any application affects only the surface, and the surface must be kept coated, thus preventing the spores from germinating and starting a growth in the tissues of the leaf, for then it cannot be reached. Applications of Bordeaux mixture should be begun as soon as first leaves of plant appear, and should be repeated every eight or ten days for six or seven weeks. Fewer sprayings might possibly do, but it is better to err by giving too many than to run the risk of the fungus getting a foothold by giving too few. The melon raiser must begin spraying early, as above indicated; if he delays, *his work and material are wasted.* A Knapsack sprayer might be profitably used for the first few applications, but after the vines are larger, and call for more liquid, a spray pump and barrel are desirable. Further, the grower must distinguish between this blight and the wilt caused by a bacterial organism, since the Bordeaux does not affect the latter. Plants showing this wilt should be destroyed at once.

What is known as the 4.4.40 sol. of Bordeaux is used for this work, and it is made as follows: Dissolve four pounds of copper sulphate (blue vitriol) in four gallons of water in a tub or crock; slake four pounds of good quick lime slowly, adding water as it slakes to make four gallons. When wanted for use, and it should be used very shortly after it is made and not kept for some time, add sixteen gallons of water to each mixture, lime and blue vitriol, and then pour the two solutions together. Do not mix the solutions *before* diluting.

It is eminently essential that the Bordeaux mixture be not acid, in order that it may not burn the foliage. There are various tests to determine whether it is or is not acid:

1. If a clean knife blade held in the solution a minute or two becomes copper coated, more lime should be used.

2. If a little of the solution be poured into a shallow dish, and one gently blows across its surface, a thin film should form; if it does not, add more lime.

3. Buy a few cents worth of ferrocyanide of potash, dissolve it in water. To a little of the Bordeaux mixture in a glass or crockery dish add a few drops of the ferrocyanide of potash solution; if a brown color appears, the Bordeaux is acid, and more lime should be added, and the test repeated.

These frequent applications of Bordeaux, if it is properly made and properly applied, will keep the blight in check, and will in a great measure also prevent insect attack. The insecticidal qualities of the mixture could be bettered by adding four ounces of Paris Green (or one gallon of arsenate of lead) to every fifty gallons of Bordeaux.

PRELIMINARY REPORT UPON WORK AGAINST THE DESTRUCTIVE LEAF HOPPER.

This injurious insect and its work in nurseries were discussed in the report of last year, and it was then announced that an active campaign against it would be inaugurated in the summer of 1904. In the meantime, having met with Professor Stedman of the Missouri Station, I was struck by his description of a spraying machine, planned to spray four rows of nursery trees at the same time, which he had had made in his state. He very courteously gave me a general description of the outfit, the plans for which I have followed in Minnesota in a general way.

THE CART.

It seemed, however, desirable to bring the reservoir below the platform in order to better balance the cart, and since three or four-year-old trees in Minnesota are not as tall as trees of the same age in Missouri, we found it unnecessary to make the cart as high as the one used in the state south of us. Therefore, while Stedman's plan was followed in the main, the cart we constructed differs from his in many minor details. This outfit is intended for use in large nurseries, and on level ground.

Fig. 84 shows the cart as it was first made for use with kerosene emulsion. The wheels are 5½ feet in diameter, with 4-inch tires, and the platform, which is 8x4¼ feet square, is 14 inches above the wheels, well balanced on the axle, so that almost all the weight, practically all, comes on the axle, not on the horse. The lower hori-

Fig. 84.—Our Spraying Outfit at work in Nursery. Fitted with one Simplex Pump and one Kero-water Pump. Only the latter in use.

zontal pipe D (see Fig. 85) is 1 inch, and 10½ feet long. Just 3½ feet distant from each other on this pipe four nozzles are attached, pointing directly downward. This spacing brings each one of these nozzles directly over a nursery row, where the rows are three and one-half feet apart, the usual distance. A nurseryman can, of course, suit this distance to the space between the rows in his nursery. Horizontal pipe D can be raised or lowered by means of chains, to suit high or low trees.

Horizontal pipe C is fourteen feet long, and projects ten inches back of the platform. The three-eighth-inch verticals from this pipe are five feet four inches long, three and one-half feet space between

them, and cross pieces at the bottom, so arranged that the nozzle at each end of each cross piece points up at an angle of 45 degrees. This spacing, with that between the nozzles on the upper pipe, results in a copious spray coming both from above on the tops of the trees, and from below against the lower surface of the leaves, the latter being a very important feature. In actual practice the trees are completely surrounded by a fine spray, so that insects, whether they be upon the upper surface of leaf or twig, or the lower surface, or whether, disturbed by the spraying, they seek to fly away, are sure to be caught by the deadly mist. A glance at Fig. 85 will enable one to appreciate these details. In this drawing the two pumps, which, as intimated

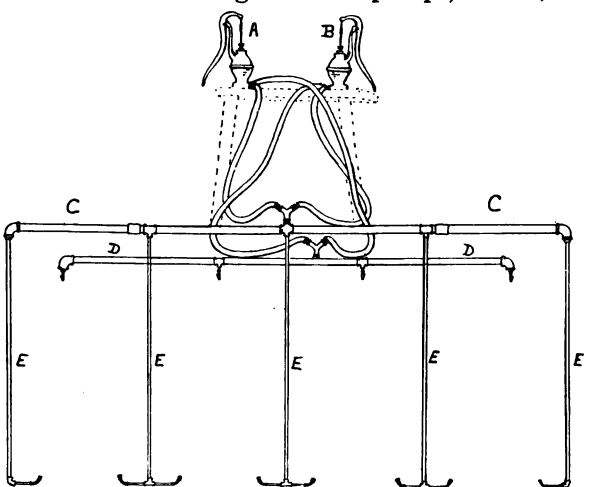


Fig. 85.—Details of Spraying Outfit.

above, were intended to be used with kerosene emulsion, are shown, and the two pieces of hose running from each to the horizontals. The double hose from one pump can be joined to either one of the horizontals, or to both, or the four pieces of hose from the two pumps can be so connected with the horizontals that the working of both pumps will contribute to the force in both pipes, and, therefore, in all the twelve nozzles. This latter arrangement seemed at first necessary, for we supposed that both pumps would be required to make all the nozzles do effective work. As a matter of fact, when emulsion was used, one pump worked by one man was all that was necessary to bring good results at the nozzles. The two pumps used with kerosene emulsion were both "Simplex" pumps and answered the purpose perfectly. It is evident that such an outfit could be used with any

spraying compound (except Kero-water), which it was desired to apply to nursery trees. Our tank, resting on a platform between the wheels, readily seen in the photographs, was made out of strong galvanized iron and was two feet ten inches in diameter and three and one-half feet high, holding about 165 gallons; a faucet at bottom behind allowed the emptying of the tank at any time. A fourteen-inch square hole on top with cover afforded opening for filling.

A heavy and steady horse was used with the cart, and an old saddle on the back of the animal seemed to relieve his back of any undue strain. However, as stated above, the weight was so well balanced on the axle that the outfit was not at all severe on the horse, and was drawn when the tank was from one-half to two-thirds full with apparent ease.

WORK IN THE FIELD.

The tree hopper was first observed this season in various nurseries early in July; on July 4th in one in Southern Minnesota, where it rapidly grew very abundant. On July 8th it was found to be doing destructive work in another large nursery in Southern Minnesota, and was abundant on the Station grounds from about July 15th. It was also found to be very bad in nurseries in Southeastern Minnesota and extremely abundant in Wright county nurseries on July 21st.

One of the large nurseries referred to above was chosen as the field of our experimental work. We had planned to spray early in July, but owing to delay in getting the cart completed, the first spraying was not given until July 14th, at least ten days later than intended. At that time kerosene emulsion was used at the rate of one part of stock emulsion to twelve parts of water. The machine worked perfectly, one man and one pump being sufficient to envelope each tree in the row in a complete fog. In this fog were thousands of hoppers flying from the trees, but unable to escape the spray.

This strength of emulsion, however, while it killed the young hoppers, did not permanently affect the adults. We therefore, on July 19th, increased the strength, using one part emulsion to ten of water. This in no way injured the trees, nor did it, unfortunately, kill the adults, which were very numerous at that date.

Learning from the Missouri Station that they were using a mechanical mixture of kerosene and water (10 per cent), with considerable success, I sent for a Kero-water pump, known as the "Peerless," which is seen in one of the photographs (Fig. 84) fitted to the

cart by the side of the "Simplex." This pump is so connected with a tank which can be filled with kerosene that every stroke of the handle not only draws water from the water reservoir through one pipe, but also, at the same time, a regulated amount of kerosene from the kerosene tank, the oil and water mixing mechanically, and issuing from the nozzles as a fine spray, the so-called Kero-water mixture. This is very effective, easy to prepare, in fact it calls for no preparation, as the kerosene emulsion does, and easy to apply. Unfortunately, the writer has yet to see one of these Kero-water machines which

Fig. 86.—Hand Dust Sprayer at work.

pumps true to the indicator. Our experience has been that if the indicator points at 10 per cent one is not at all sure of obtaining that percentage of oil in the water, in fact, he is quite sure not to. When the indicator of our "Peerless" pump "indicated" 20 per cent, we found by actual test that we were pumping 10 per cent, 25 per cent register giving 15 per cent. With the indicator at 30 per cent we obtained 25 per cent, while 50 per cent on the indicator gave nearly 50 per cent by actual test as it came from the nozzles. The indicator's 10 per cent and 15 per cent gave such a small per cent of oil, far below the figure indicated, as to be practically worthless for our purpose. We found further that when the oil in the oil tank got quite low, the per cent materially changed; for instance, with the indicator at 25 per cent we pumped 15 per cent steadily until tank was nearly empty, when test showed that we were getting only 5 per cent. This inaccuracy and variation is common to all the Kero-water pumps

with which we have had experience, and is a serious objection to their use. Nevertheless, once understood, and frequently tested in the field, these machines do good service.

Our Kero-water outfit arrived too late in the season to be of really practical benefit. It was used August 5th for the first time, and Kero-water of 15 per cent applied. At that date the hoppers were becoming decidedly less in number, and further, the pump could only supply liquid sufficient to fill the lower nozzles. This difficulty was overcome by obtaining another pump, so that next season we will be prepared at the very outset to put up a good, and, I believe, a very successful fight against this pest, which is costing the nurserymen several hundred dollars' loss annually. Mr. Robert Wedge, under

Fig. 87.—Cyclone Dust Sprayer.

whose supervision the spraying was done, wrote this department under date of August 11th, six days after using the Kero-water spray, that he could "see no bad effect on the foliage of the apple trees sprayed with 15 per cent mixture."

We have already alluded to the statement from Missouri that 10 per cent Kero-water mixture appears to be effective against the adult hopper. In spite of Mr. Wedge's statement that 15 per cent did not appear to injure foliage, from observations along this line at the Experiment Station, the writer is induced to believe that 10 per cent is much safer than 15 per cent in this regard.

At Adrian, Minnesota, Mr. Fred Mohl, proprietor of a large nursery, has kindly co-operated with the Entomologist, and has been making a series of experiments with the dust spray. Figs. 86

and 87 show the Cyclone Dust Sprayer in operation, Fig. 86 representing the hand machine, and Fig. 87 the larger machine used on wagon. Mr. Mohl sprayed twice with the "Caustic Lime" mixture, and once with the "General Formula." At the date of my visit, in July, the trees were looking very well, though they were not free of leaf hoppers. He is of the opinion that if he had begun earlier, "before the hoppers appeared" as he expressed it, and sprayed three times, he could have kept them well under control. While the writer is quite willing to be convinced, he has not absolute confidence in the perfect efficacy of dust spraying. For many fungus diseases and some insects, and under certain conditions where liquid cannot be used, it is unquestionably an excellent thing, as shown by the vigorous appearance of Mr. Mohl's trees, but in the case of the leaf hopper we have doubts. We would be very glad indeed to have these doubts removed, and its extreme usefulness demonstrated.

Mr. Mohl is an enthusiast as regards dust spraying, as shown by the following extracts from letters from him, the first written on February 24th, and the latter, referring to the effect of spraying his orchard, on July 25th.

"I have your favor of the 23rd inst. regarding campaign against the leaf hopper and was glad to hear from you on this subject as I have for years been bothered with these leaf hoppers not only in the orchard but also in the nursery. With the old method of spraying, it has been hard to reach them as they get on the under side of the leaf, which curls up and with liquid spray you cannot get to them, unless, perhaps, by persistent early spraying, which may keep them away. This year I intend to give the dust spray a thorough test and will begin the first spraying before the leaves come out. I intend to buy another small dust sprayer in addition to the Cyclone sprayer which I have. This smaller machine can be carried about and will come handy to fight the enemy as it appears. I shall also buy the prepared dust as per circular which I enclose.

"In the orchard where we sprayed with the Caustic Lime twice and once with the General Formula, we can find scarcely any leaf hoppers, and, in fact, no insect pest of any kind. I am of the opinion that if we had begun spraying in the nursery before the enemy

---

NOTE.—The "Caustic Lime" formula consists of ground lime, sulphur and concentrated lye. The "General Formula" is made of ground lime, "sal. Bordeaux," sulphur and Paris green.

appeared and sprayed with the Caustic Lime, say about three times, there would have been but a few hoppers. Some varieties appear to be more affected than others. * * * I am yet of the opinion that if the dust or dry Bordeaux is as effective as the liquid, a tree can be much more thoroughly sprayed than with liquid, and in less time and with less work." In a later letter Mr. Mohl states that he sprayed the nursery only once, with Caustic Lime, after the hoppers appeared and that it did not destroy them.

In certain experiments at the Station during the season, in connection with the leaf hopper, we found that one part of emulsion to twelve of water, when liberally applied to young nursery trees, will sometimes slightly burn some of the leaves of young apple trees if applied freely in hot sunshine. Under favorable conditions, however, we have used it as strong as one to ten without appreciable injury.

Incidentally, observations were made upon the stability of kerosene emulsion when mixed with water. We found that when one part emulsion was used to twelve of water, the separation of the oil began immediately, and the mixture could not be used safely after 15 hours; one part of emulsion to eight of water gave almost as bad results, while one part of emulsion to six of water was very much slower in separating. We found further that 10 per cent Kero-water could be used with safety as regards the foliage, was death to plant lice, and apparently fatal to old as well as young tree hoppers.

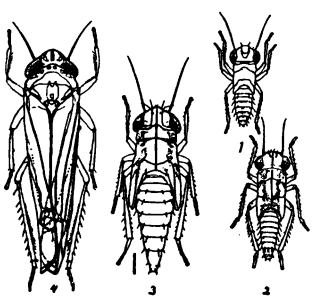


Fig. 88.—Different Stages of the Leaf Hopper, *Empoasca mali*, Osborn. Original.

Fig. 88 represents the different stages of this tree hopper from shortly after hatching to the adult stage. It has been found on a number of trees and plants other than apple. In the case of the latter tree it would appear from evidence at hand that the egg is laid by the adult in the tissue of the leaf, since young are found on the under side of the leaf, of such a tender age as to preclude the possibility of their coming from any but a nearby source. Yet in the absence of conclusive evidence the Entomologist hesitates to regard the above probability in the light of a fact.

Mr. Robert Wedge, who did considerable work against the hopper in Southern Minnesota last summer, under the writer's direction, reports that this insect's attacks are least apparent on the Northwestern Greenings, and most evident on the Repka, Charlamoff, Lyman, Minnesota and Transcendent, these five varieties being about equal sufferers. After the Repka, according to this correspondent, Scott's Winter appears to be quite badly affected, and then in diminishing ratio, Patten's Greening, Early Strawberry, Sweet Russet, Malinda, Longfield, Duchess, Hibernal, Wealthy, Whitney, Peerless, Anisim.

USES TO WHICH THE ABOVE CART MAY BE APPLIED.

The pictures of this spraying machine illustrate what may be the steps in the evolution of something of special adaptation to the needs of all tree growers. As it is now constructed it can be used with Kero-water mixture, or kerosene emulsion, or lime and sulphur spray, or resin wash, or Paris green, in short, with any of the sprays commonly used by nurserymen or orchardists against plant lice, leaf hoppers, caterpillars, scale, and other leaf-eating or sap-sucking insects. It is so large that it is adapted particularly to large nurseries on level ground. The expense of its construction would place it perhaps out of reach of the small growers, but nevertheless a number of nurserymen of the same locality could share the expense and the advantages of such a machine with considerable profit. Further, the possibilities foreshadowed in the success of this cart as a sprayer are practically unlimited. A cart to straddle one row and spray the straddled row and the two adjoining rows could, in the opinion of the writer, be easily constructed. These carts, too, including the one we are now using, could be made automatic by connecting the pumps by proper gearing with the wheels.

This work against the leaf hopper will be continued next summer, and begun at the very first appearance of the insect.

SPRAYING AND SPRAYING MACHINERY.

This is a hackneyed subject in many states where fruit raising plays an important role, but has never been thoroughly discussed in Minnesota reports in the light of what we now know upon this

important adjunct to agriculture. It is claimed that the annual loss on crops in the United States from insects and fungi ranges from $300,000,000 to $500,000,000, and that 75 per cent of this can be saved by judicious spraying. Our state is not only taking a stand as a fruit-raising state, but the conditions of raising vegetables, root crops, etc., have become such that frequently spraying is an imperative necessity. The Entomologist has been asked by agriculturists and horticulturists to discuss this subject fully, since in many instances money and time are wasted through ignorance of the essential principles of spraying, coupled with a lack of knowledge of the habits of certain insects. Some insects eat the surface of twig, or leaf, or bud, or fruit, and can be killed with internal poisons such as Paris green, arsenate of lead, London purple, hellebore and the like. But others, from the fact of their inserting a beak and sucking the sap from below the surface, cannot be reached by any arsenical or other poison applied to the surface, but must be sprayed or washed with some oily or soapy mixture, such as soapsuds, whale oil soap, kerosene emulsion, petroleum and the like, something which will stop up the spiracles (little holes along the side of the body through which they breathe), or will so irritate or burn the surface of their bodies, sometimes also stopping the spiracles, as to cause death. Such agents are found in tobacco water, pyrethrum, lime, sulphur, lime-sulphur (and salt) solution, potash, lye, etc.

We can therefore readily divide Minnesota insects into two well marked groups, those which are mandibulate or biting, and those which are haustorial or sucking. Under the first class we have cut worms, army worms, potato beetle or "potato bug," codling moth or "apple worm," currant worms, wire worms, borers, plum curculio, tent caterpillars, canker worms, pear and cherry slugs, cucumber beetle, sometimes wrongly called "squash bug," and many others; in short, all insects which have biting mouth parts when they attack our crops. Under the second class—sucking insects—we have chinch bugs, all plant lice, leaf hoppers, true squash bugs and scale insects.

Do not therefore use Paris green or any internal poison against plant lice or bed bugs, both of which mistakes on the part of our citizens have come to my notice.

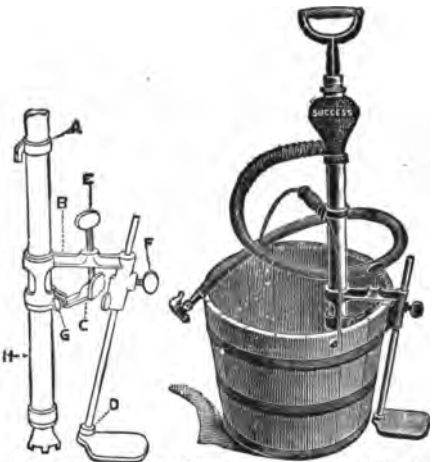


Fig. 89.—Bucket Spray Pump. Approximate cost without Bucket, $7.00.

Fig. 90.—Pump on Barrel, Showing Agitator. **Approximate cost without Barrel, $16.00.**

THE PUMP.

This is a very important factor in successful spraying. In purchasing a pump one will be guided by his needs; if it is wanted for a few shrubs and small trees in the yard, for use in a small vegetable garden, or for whitewashing a hen house, a bucket pump such as is shown in Fig. 89 will do, bearing in mind that the bucket or can will have to be carried from place to place and frequently filled. Hence, if a number of potato plants or other plants are to be sprayed in the vegetable garden it might pay one to get a pump which can be fastened to a barrel which could be hauled about on a wagon or stoneboat. Such pumps, with approximate cost in each case, are shown in Figs. 90 and 91.

Do NOT buy a syringe pump, which costs from $1.00 to $2.50 or $3.00 and throws only a very coarse spray, and think you have anything of value. A plant syringe is all very well in a conservatory, but valueless if any number of shrubs and trees are to be treated, and even conservatory or house use calls for something which will administer the liquid in a fine spray and with force.

Do NOT allow your home dealer to sell you a cheap pump

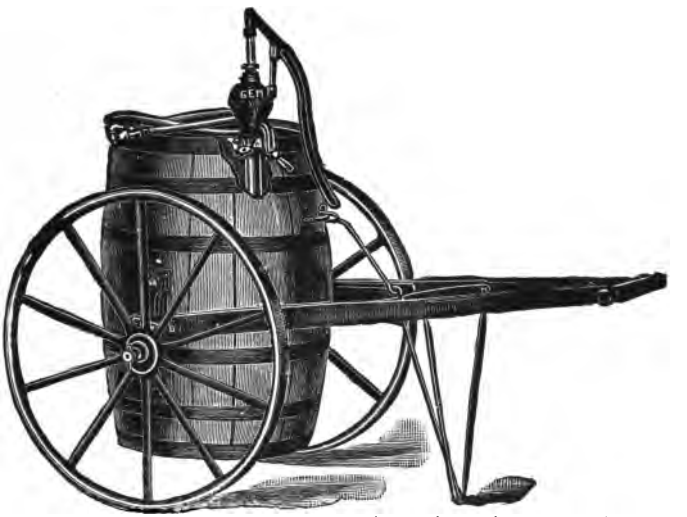


Fig. 91.—Barrel Cart and Pump, complete. Approximate cost, $9.00.

($3.00 to $8.00) for garden and orchard, on the ground that it is "just as good." It is not as good, as you will no doubt find later to your cost, should you be persuaded to purchase it. We append be-

Fig. 92.—Small Sprayer for use in greenhouse or garden. Tin, 60c.; Brass Reservoir, 85c.

low a list of manufacturers of spray pumps, and a good pump should show the name of some one of these as a guarantee of

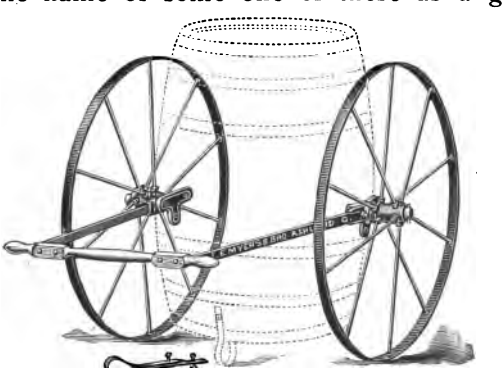


Fig. 93.—Steel Cart for Barrel and Pump.

its excellence. A good pump is one whose parts do not easily corrode. The working parts should be of brass. Leather or rubber valves are not used in the best pumps, but are replaced by brass valves. Cylinders lined with porcelain are not desirable.

A farmer or fruit grower should be willing to pay anywhere from $9 to $20 for a good pump. Automatic and power sprayers, for use in large orchards, and on extensive field crops (See Figs. 97, 98, 99, 100) come much higher. He should insist upon seeing the interior of a pump before buying. Several might unite in buying a pump, thereby being able to purchase a good article with comparatively small expense to each individual.

Fig. 94.—A Barrel Cart.

Connections of good hose are important, and poor hose should be avoided; three-ply and four-ply are generally used, but where great pressure is to be planned for, five-ply or even six-ply is desirable. Hose can be bought of any length, and where trees of some height are to be sprayed (10 to 20 feet) extensions are necessary. These can be bought of various lengths, and consist either of metal pipe alone to the ends of which the hose and nozzle is attached, or the same encased in bamboo. Drip guards which encircle the extension just below the nozzle, or just above the point where it is held will add to the

comfort of the man spraying by catching liquid which would otherwise run down the pole upon his hands. In submitting the following list of manufacturers, taken from Geneva Bulletin No. 243, we must remind our readers that some of these firms have agents in different cities in Minnesota. In such cases, the manufacturers would not quote any better price than the agents. A request for a catalogue price list, mailed to any one of the following firms, would doubtless meet with immediate attention.

E. C. Brown & Co., Rochester, N. Y.
Dust Sprayer Mfg. Co., 510 Broadway, Kansas City, Mo.
Deming Co., Salem, Ohio.
W. & B. Douglas, Middletown, Conn.
Field Force Pump Co., Elmira, N. Y.
Friend Mfg. Co., Gasport, N. Y.
J. F. Gaylord, Catskill, N. Y.
Goulds Mfg. Co., Seneca Falls, N. Y.
Hardie Spray Pump Mfg. Co., Detroit, Mich.
H. W. Henry, LaPorte, Ind.
Hillis Dust Spray Mfg. Co., McFall, Mo.
Leggett & Bro., New York.
J. J. Kiser, Stanberry, Mo.
Morrill & Morley, Benton Harbor, Mich.
F. E. Myers & Bro., Ashland, O.
Niagara Spraying Co, Middleport, N. Y.
Pierce-Loop Sprayer Co., North East, Pa.
Rochester Machine Tool Works, Ltd., Rochester, N. Y.
Rippley Hardware Co., Grafton, Ill.
D. B. Smith & Co., Utica, N. Y.
Spramotor Co., London, Ont., and Buffalo, N. Y.
Wm. Stahl, Quincy, Ill.
Wallace Machinery Co., Champaign, Ill.
R. B. Williamson, Clifton Springs, N. Y

THE NOZZLE AND THE SPRAY.

A spraying outfit without a good nozzle is like the play of Hamlet with Hamlet himself omitted; in other words, the outfit is practically worthless unless it is well equipped in this particular. This leads us to speak of a most important point in this connection, namely, the *liquid must be applied in the form of a mist, or very fine spray, and must strike the fruit, leaf or twig with force.* A nozzle *which will not do this is, with the exception noted below, of little or no value,* as far as

Fig. 95.—An Automatic Sprayer. Cask holds 10 gallons. Wheel 26 inches high, 3-inch Tire. Weight of outfit, 75 pounds. Price complete, as shown, $24.00.

treatment against insect pests is concerned. Do not think that a mere sprinkling is going to do the work. Note, in this connection, that the old-fashioned field sprinkler which used to be employed in putting Paris green solution on potato vines has been replaced by the modern cart, geared to pump automatically, and furnished with nozzles which apply the liquid in a fine spray and with force. This is economy, for when there is but a coarse spray, or if the nozzle "dribbles" the liquid is wasted. It is economy too, while seeing that every leaf and every part of the fruit or twig, whatever one is treating, is well covered, not to waste the liquid by spraying too much, that is, the liquid should not drip off, or run off the tree or plant to any great extent.

In purchasing a nozzle, get one which can be readily cleaned, for even with care in straining the liquid, some particles of foreign matter will occasionally clog the nozzle. We have found the Vermorel

Fig. 96.—Spraying Outfit for high trees.

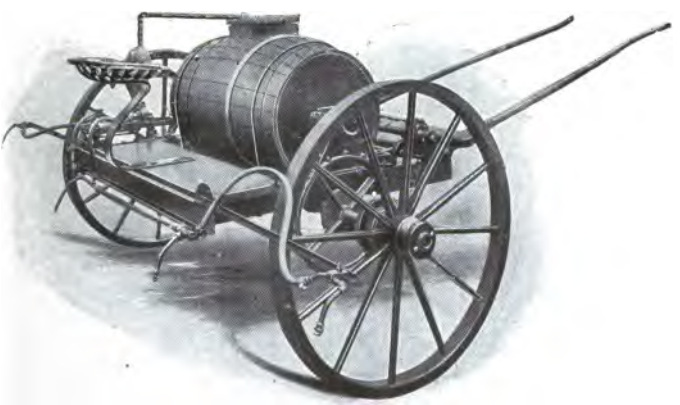


Fig. 97.—Automatic Field Sprayer, Six rows. Approximate cost, $67.50.

nozzles excellent in this particular, and making a spray fine enough and forcible enough for all purposes. When Bordeaux mixture or lime-sulphur-salt mixture, or a whitewash is to be used I change the Vermorel for the Bordeaux nozzle, which is better adapted to these compounds. This is the exception referred to above.

Fig. 98.—Automatic Field Sprayer, Six rows. Approximate cost, $72.50.

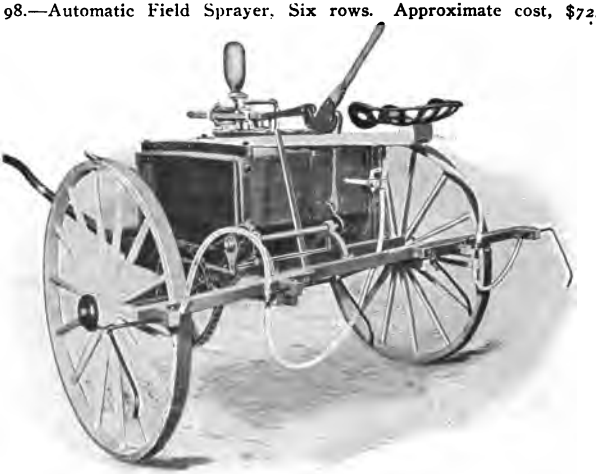


Fig. 99.—Automatic Field Sprayer, with five rows of brass piping. Approximate cost, $90.00.

STRAINERS.

All compounds used for spraying should be strained before or while being poured into the barrel or other receptacle from which they are to be drawn by the pump. If possible avoid using burlap for

this purpose, since if used lint is bound to be carried into the pump and is likely to bother you by clogging the nozzle. Brass strainers are the best, made to fit the opening through which one pours the liquid. In addition to this, every good pump has a strainer in the lower end of suction pipe or suction hose through which the liquid is drawn into the pump.

AGITATORS.

Fig. 100.—Power Sprayer mounted on Wagon.

Most pumps—all good pumps—are equipped with agitators which, as a rule, the working of the pump handle keeps in motion. These are generally paddles which keep the liquid in the barrel or other receptacle constantly stirred. *Paris green being heavier than water, sinks if the liquid is not kept constantly in motion*, the result being that the poison is unevenly distributed, and a part of the tree or a portion of the plant will be injured or killed

Fig. 100½.—Six-row Sprayer in Field.

by receiving an unnecessarily large amount of the green, while other parts will receive little or none. Should one be using Paris green in solution from a bucket, this should be borne in mind, and the solution almost constantly stirred.

TANKS FOR FIELD USE.

Fig. 101.—Three-row Sprayer at work in field of Strawberries. It is claimed that one man can drive and work the machine. Price of Hose, Piping, Nozzles and Connections (without the pump), $7.50.

These can be made of galvanized iron or pine (cypress is said to be the best of the woods for this purpose where obtainable) or cedar. When made of wood the inside should be painted. Two horses cannot comfortably draw more than 250 gallons of liquid over the field.

Fig. 102.—The "Auto Spray." Holds four gallons. The hand in the engraving is out of all proportion. Tank is of steel or brass. Compressed air. Weight, when loaded, 39 Pounds.

KNAPSACK SPRAYERS

Machines intended to be carried around on back, or lifted about by hand when desired, and excellent for work with shrubbery or in garden where too much ground is not to be covered. The writer speaks from personal experience when he says that after several fillings the weight tells upon one's back and shoulders. See Fig. 112.

Fig. 103.—Vermorel Nozzle. Cost, 80c.

Fig. 104.—Improved Vermorel Nozzle.

Fig. 105.—"Bordeaux" Spray Nozzle. Cost, 80c.

KERO-WATER SPRAYERS.

These are machines made both in knapsack form, Fig. 112, and to be used with barrel, Fig. 113, possessing a receptacle for kerosene so connected that every stroke of the pump handle draws some of the oil from the oil tank and it is mechanically mixed with the water, issuing from the nozzle in what we call the "Kero-water spray." This has the advantage over kerosene emulsion in that it eliminates the making of the latter, and hence is a saving of time. It is, of course, cleaner than the emulsion and easier to handle. Ten per cent of oil and 90 per cent of water, or 10 per cent Kero-water, as it is called, is very effective against many sucking insects, and ordinarily does not injure the foliage. A valve and graduated disk on these pumps is supposed to afford an opportunity to obtain 5 per cent, 10 per cent, 20 per cent of

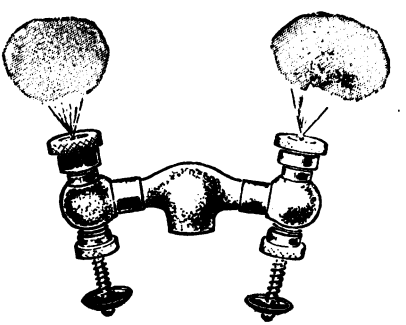


Fig. 106.—Double Vermorel Nozzle.

oil and upwards, according to the needs of the operator. Unfortunately in all the pumps with which the writer has had experience, the per cent of oil indicated is not always the per cent obtained. Further, it has been our experience in the field to find that a Kero-water pump which is delivering say 15 per cent Kero-water at one time, may drop to 5 per cent when the water or oil in the receptacles gets low. However, the first of these defects can be overcome by testing, preferably, with a glass graduate, your own machine before it is used, and making memoranda of what the indicated per cents on the disk really are in practice. We found that 5 per cent and 10 per cent could not be relied upon at all, see page ——; that 20 per cent really gave 10

Fig. 109.—Bamboo Extension.

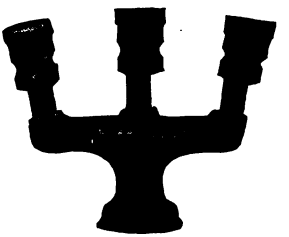


Fig. 110.—Three-cluster painting Nozzle.

Fig. 107.—Double Bordeaux Nozzle.

Fig. 108.—Double acting Pump. Approximate cost, $36.00.

per cent, etc. Any glass jar or bottle with straight sides can be used in this test to obtain an approximately correct reading of the proportionate amount of water and oil. Catch the spray as it issues from the nozzle, and let it stand until all the oil has gathered at the top of the water. If there is one-fifth as much oil as water, your pump is giving you 20 per cent kerosene; if one-tenth as much oil, 10 per cent kerosene or Kero-water; if one-half as much oil, 50 per cent Kero-water and so on. It has been found necessary

in the field to frequently test one of the Kero-water pumps which we are using (see page 88), in order to post ourselves as to just what strength we were giving the trees.

DUST SPRAYERS.

The simplest form of dust sprayer is found, perhaps, in the little bellows sold at drug stores, and used to distribute pyrethrum in cracks and crevices which might conceal fleas or bedbugs. A larger bellows is made for use with plants, and a still more complete machine for field use is known as the Leggett London Purple Gun, Fig. 115, with which one can distribute lime or a mixture of lime and Paris green, flour and Paris green, hellebore and like material. More recently, at least two firms have manufactured dust sprayers on a larger scale, to be placed on wagons, and intended for use in large nurseries or orchards. One called the "Cyclone Sprayer," and made in Kansas City, is figured herewith, Fig. 116. This machine and a smaller one made by the same firm are shown in use on pages 88 and 89. A dry Bordeaux and certain caustic compounds are used with these sprayers, or a combination of dry Bordeaux and Paris green are manufactured, though directions are given to purchasers whereby many of these compounds may be made at home. The claims made by the manufacturers and several of the users of dust sprays are many: They say there are no barrels of liquid to be hauled, and this is of great value where it is hard to carry or obtain water; that the cloud of dust envelopes immense numbers of trees, sometimes covering an entire orchard; that it is imposible to get too much of the spray; that it costs less than the manufacture and application of liquid sprays, etc. These advantages, barring the item of less expense, which must vary, are self-evident. On the other hand there are certain disadvantages in this method equally apparent, namely: When a strong wind is blowing it cannot well be used, one being obliged to keep to the windward side

Fig. 111.—Double Vermorel with Y.

Fig. 112.—Knapsack Sprayer.

of the trees constantly; it is best used apparently when the dew is on trees and plants, thus relegating the work to the morning hours; it is not apparently effective against the codling moth; one has to personally avoid the dust and see that it does not settle on the horses; for sucking insects, in the opinion of the writer, nothing is so good for summer use as kerosene emulsion or Kero-water; arsenate of lead, which is coming into universal favor as a safe remedy for insects which eat leaf, or fruit, or twig, bud or bark, cannot, of course, be used as a dust spray.

Fig. 113.—Kero-water Pump on Barrel. Approximate cost of Pump mounted on barrel (without hose or nozzles), $21.00.

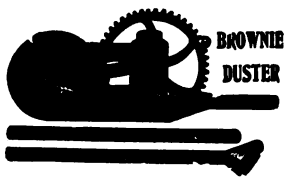


Fig. 114.—The "Brownie Duster." A small Dust Sprayer for use in conservatory, greenhouse or garden. Cost, $3.50.

I do not wish to be understood as in any way condemning the use of dust sprays, for they certainly stand for an advance in our means of attacking injurious insects, but it would be unwise not to consider the disadvantages in their use as well as the advantages. I do not believe they will ever entirely replace liquid spraying.

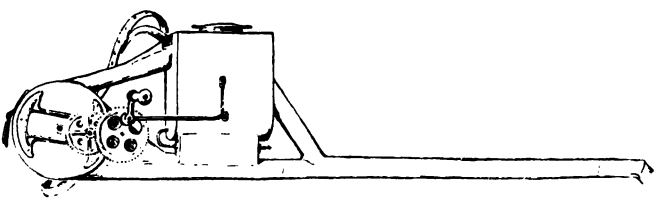


Fig. 115.—Leggett London Purple Gun.

INSECTICIDES AND FUNGICIDES.

A very complete list of spraying compounds for both sucking and biting insects, and for the more common fungicides used against fungous diseases which attack fruit trees, vines, etc., was given in the Annual Report of the State Entomologist for 1903, and need not be repeated here. The report referred to can be had for the asking.

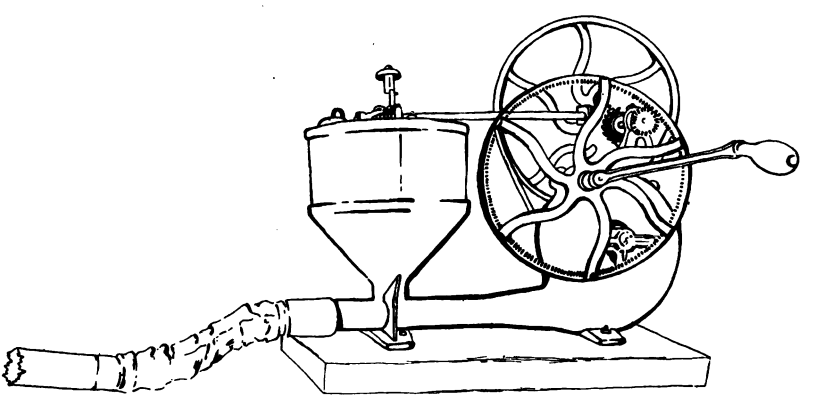


Fig. 116.—Cyclone Dust Sprayer for use on wagon. Approximate cost, $22.00.

Fig. 117.—McGowen Injector. For putting bi-sulphide of carbon about roots of trees or plants. Slingerland.

THE PLUM CURCULIO AN ENEMY TO APPLES.

(Paper read before the State Horticultural Society at its 1904 meeting.)

That this pest, which we associate so commonly with plums, does attack apples, is not a new fact, since this departure from the orthodox food habits has been known for some time; but since apple-raising in Minnesota is, practically speaking, in its infancy, this naughty feature in the life of this weevil, illustrated by the loss, in at least one instance, of 100 per cent of the apple crop in a Southern Minnesota orchard last season, is unceremoniously brought to our door in a very emphatic and unpleasant manner. Fourteen other orchards have suffered, to my certain knowledge, and there are probably many other instances of its work in apples in this state not known to me. I might add that I placed some of these injured apples in a breeding jar and in September had a fine lot of Plum Curculios from the same.

There is no doubt but that this Curculio is to be regarded quite as much of a pest to the apple in Minnesota as the Codling Moth, or even more so.

This Curculio belongs to the family of beetles known as "Snout Beetles" or weevils, of which there are about 10,000 known species, which family causes a loss of over $30,000,000 annually in the United States. It is unnecessary to state that our little friend with the humps on his back, the Plum Curculio, does all he can with other members of his family to keep up his reputation as an evil-doer.

As a result of this weevil's attack on the apple we find the fruit dwarfed, misshapen, covered with ugly scars, looking like Fig. 120, and actually worthless except for hog food, as it falls to the ground.

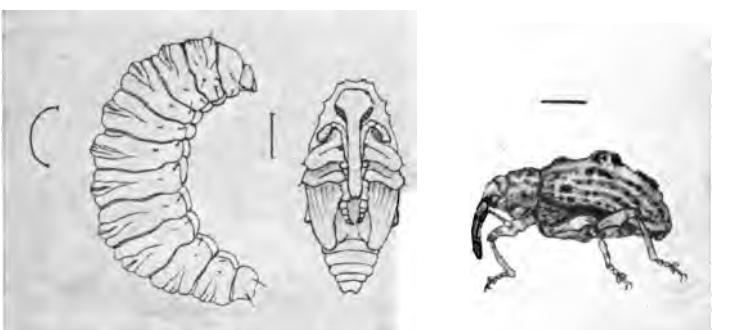


Fig. 119.—Plum Curculio, larva or grub, pupa and imago. After Lugger.

If one cuts into one of these apples during midsummer, in July say, the small whitish grub is disclosed, actively engaged in boring through the fruit, and waxing strong and fat, preparatory to the time when, the apple fallen, he or she, as the case may be, will enter the ground to pass through a resting stage or pupal stage of two or three weeks, before turning into the imago, or perfect insect. This takes place before fall, generally in August, but the beetle does not mate upon emergence from the pupal stage. Its first instinct is to eat, and after lunching upon fruit for a while, by puncturing the apples, it winters under rubbish and leaves, deferring its courtship until the following spring. The first warm days of spring, after the fruit is formed, find the lady Curculio laying her eggs. Although the insect is single brooded, she continues egg-laying for some little time, probably

through the latter part of May and June, and later, as though she were conscious that she had to do all she could before dying in the late summer or autumn. Now, insects must eat, as we all know to our cost, and while she is egg-laying she, as well as the male, feeds upon tender leaf buds and leaves, and upon the fruit also. Before the fruit is large enough to tempt her to lay, in fact before it has formed, and probably before she has mated, she varies her diet of leaf buds by consuming the petals of the flowers as well. For obvious reasons we cannot spray when the tree is in bloom. This eating of leaves and leaf buds is a significant fact and a habit on the part of the insect which should be taken advantage of by fruit raisers. The method of egg-laying by the Plum Curculio, shared to a certain extent by other

Fig. 120.—Minnesota Apples destroyed by the Plum Curculio. Original.

members of the weevil family, is curious enough. She first punctures and eats a small hole into the pulp of the fruit. She then turns about and lays one oval, whitish egg in this hole. Her next move is to make a crescentic cut on one side of the egg puncture, eating the tissue until she gets partly around and below the egg. This is the usual method followed, though it may vary in minute detail. Evidently this crescent, which practically undermines the egg, is made so that the tender egg may not be crushed by the growing pulp of the apple or plum.

Of course, if these "stings" are made when the fruit is well along in its growth, and the egg does not hatch, or if the puncture made at that time is just for feeding purposes, it does not spoil the apple, though the fruit, which would show the scar, could not then be classed as first grade, and if, for any reason, when the apple is small, the female does not lay an egg in the puncture, or if the egg fails to hatch, the young apple will probably outgrow the injury. These "stings," however, and a glance at the accompanying picture shows that there may be many, form starting places for decay and allow fungoid diseases, which would not otherwise, perhaps, gain an entrance to the interior, to enter the fruit and play such havoc that the apple is made comparatively valueless. It is said that it takes from five to seven days for the egg to hatch, and that the larva or grub lives in the apple from eighteen to twenty-one days. It is further claimed that *if the apple does not fall to the ground when the contained larva is half grown, the development of said larva stops and it dies* (Stedman).

The adult beetles have wings by means of which they fly, sometimes for long distances, in search of suitable places in which to pass the winter. It may be said, however, that they hibernate, for the most part, under the fruit trees, particularly if there is rubbish there, or if the ground is in sod which is not disturbed.

Now, in the orchard to which I referred at the beginning of this article, where practically all of the fruit was destroyed, ideal conditions appear to exist for the encouragement of this evil; an old orchard, sprayed only one year, 1902, sod growing undisturbed for several years beneath the trees, no stock of any kind allowed to run in the orchard, and numerous plum trees in close proximity. This is one of the oldest orchards in Southern Minnesota.

I have given the habits and life history of this pest in some detail, for you all know the necessity of knowledge upon these points in order to combat any pest successfully.

From the foregoing facts certain measures of relief appeal to us as practical, for instance, spraying frequently in the early spring and summer, jarring the trees in the cool of the early morning and catching the beetles on sheets below. One enterprising apple grower, however, makes the statement that he gets more Curculios by jarring between six and seven o'clock in the evening than at any other time. He uses a cheap spread, about 15 feet square, attached to poles along

two opposite sides, so that it may be easily rolled up, and having a slit to the center into which the trunk slips. Jarring the apple trees is continued by him from the time the fruit is the size of marbles until he can catch no more beetles. This seems a good rule to follow.

It should be noted in this connection that jarring means a sudden forcible blow (padding the stick or mallet used, so as not to injure the bark), not a shaking of the limb, the latter simulating the action of the wind so closely that the beetles would not be sufficiently alarmed to drop, and would cling to the twigs until the shaking ceased.

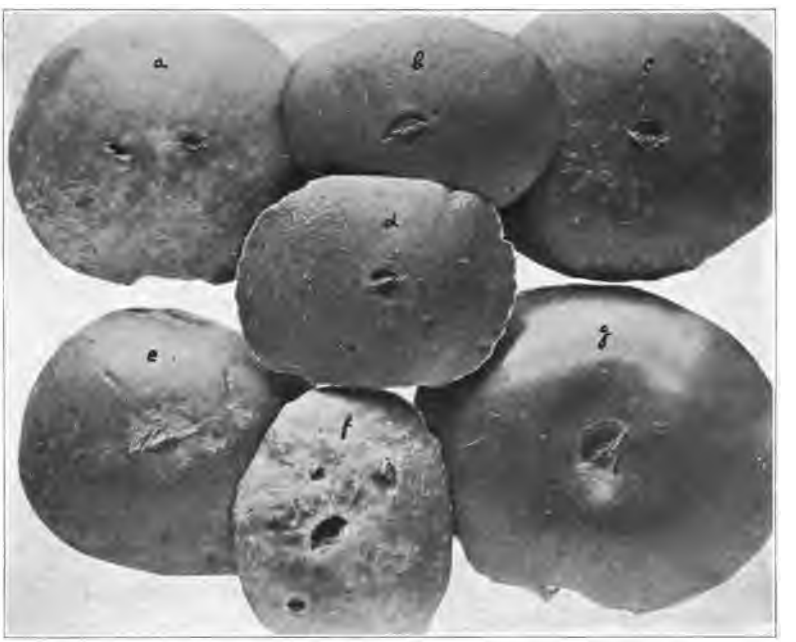


Fig. 121.—Details of injury to Apples: *a*, egg punctures with larvæ living in the pulp and the punctures beginning to decay; *b*, *c*, *d*, egg punctures beginning to heal, as eggs never hatched; *f*, badly stung portions of an apple; *e*, egg puncture nearly healed; *g*, scar in a depression. Stedman.

The ground in an infested orchard should be plowed every fall for a while, or both fall and spring, and stock, such as hogs and chickens, should have full access in order either that the fallen fruit be eaten before the grub emerges, which would be the best and safest plan, or the grub after emergence be scratched up and devoured by hungry fowls. Plum trees should not be planted in the immediate

vicinity of an apple orchard, nor should apple or other orchards be planted near a forest or wooded area, since not only does the Plum Curculio like to winter in wooded tracts, but many of our other orchard pests were originally insects of the forest. Above all it must be remembered that an ounce of prevention is worth a pound of cure, and these remedial measures must be applied in a timely way. For instance, spraying, to be of any use, must be begun before the eggs are laid, or, rather, frequent applications should be made during the entire period of egg-laying, from the middle or last of May, and before, to possibly as late as the middle of July. The writer would suggest one or two sprayings first before the blossoms open, and every ten days after the blossoms fall, until the end of the laying season, and jarring should be persevered in during this period. For spraying we would suggest using one pound of Paris green to every 160 gallons of water and the addition of a little quick lime to prevent any burning. As you are well aware, spraying in this way would also kill any other insect pest feeding upon fruit, leaf or twig. Plum trees infested with Plum Curculio should receive the same treatment. The writer would suggest using quite a little more lime when treating plums, as the plum foliage is more tender than that of the apple. A better and safer spray than Paris green, and one rapidly coming into favor, is arsenate of lead,* sometimes called disparene. This can be used of almost any strength (three to six pounds in every 100 gallons of water) without injury to trees, and remains on leaf and fruit much longer than Paris green. If a long continued and copious rain immediately follows a spraying, it is safe to conclude that much of the poison has been washed off, and spray again. I note that Stedman suggests in recent publications regarding this same evil in Missouri, the working of the soil in the apple orchard in July and August, a shallow plowing and thorough harrowing about the middle of July, followed by two more harrowings between that date and the middle of August. This would seem to be a valuable adjunct to the other work, inasmuch as it would disturb the ground at a time when the beetles were pupating just below the surface.

If not one but all the measures of relief above outlined be followed for a few years, the injury to the apple by this pest is bound to be

very much reduced, if not made to disappear altogether. Even one of the above remedial measures, if followed faithfully and intelligently, will cause a marked improvement.

---

*NOTE.—Dissolve 11 ounces acetate of lead (sugar of lead) in 4 quarts of water, in a wooden pail, and 4 ounces arsenate of soda (50 per cent purity) in another wooden pail. The sugar of lead can be dissolved more quickly by using warm water. Pour these solutions into 150 gallons of water. Arsenate of lead can be purchased already prepared.

It is important to note in this connection that if one is using Bordeaux for early spraying for scab or other fungus diseases, adding an arsenical poison (Paris green, for example) to the Bordeaux will serve good purpose against the Plum Curculio, and other leaf and fruit eaters.

THE MOTTLED WILLOW BORER, AN INTRODUCED ENEMY TO CAROLINA POPLAR AND WILLOWS.

While this tree is not, from an æsthetic standpoint, as desirable as many others, it is becoming very popular as an addition to our list of trees for windbreaks on account of its extremely rapid and vigorous growth.

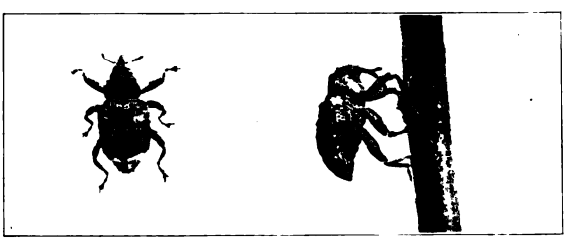


Fig. 122.—The Mottled Willow Borer, *Cryptorhynchus lapathi*, Linn., somewhat enlarged. Original.

It will interest the citizens of this state, therefore, to know that not only is this tree, but practically all the willows and probably most of the poplars, alders and birches threatened with a borer, which came from Europe several years ago, and though confined to the East for a long period, has worked its way, evidently through shipments of nursery stock, into Ohio, probably into Canada, and this

year specimens were sent to the Minnesota Entomologist from Carolina poplars received into Minnesota from New York State, and shipped from here to North Dakota, where twenty-five trees were reported killed.

This is the European alder and willow borer, *Cryptorhyncus lapathi*, Linn., shown in our illustrations. It is a snout beetle belonging to the family *Curculionidæ*, dark brown, or blackish, nearly one-half inch long, with a conspicuous whitish or yellowish (scaly) patch on the rear part of its back; these yellowish scales are seen also on its sides near its head.

It makes a hole in the poplar tree, frequently attacking a tree near the base, and in this hole deposits from one to four eggs. The white legless larva with brown head which hatches from the egg bores under the bark in the immediate vicinity of the place where it

Fig. 123.—Work of the Mottled Willow Borer in Carolina Poplar. Original.

has hatched during the first season, wintering in this position, and tunneling into the wood the second season. This boring beneath the bark, and the subsequent entering the wood will greatly injure any tree, and in the case of small trees, if the insect is in the trunk, undoubtedly cause their death. The larva, becoming full grown, transforms to a pupa at the end of the second summer, passing the second winter in this condition, and emerging as an adult beetle in the spring, the third year from the egg. In other words, two years are required for one generation. Mating and egg-laying take place after the beetle has issued from the wood.

The spread of this foreign insect westward in the United States is of interest. It was described by Linneæus in 1763; in 1824 in the vicinity of Liegnitz, a whole alder plantation was destroyed by it, willows also suffering. In some way, possibly in cuttings from

Europe, it was brought into America. In 1882 it was taken on willows in New York City; in 1884 one specimen was taken in New York State and one in Staten Island. In 1887 it was found on willows near West Bergen, New York. In 1891 Smith reports it as kill-

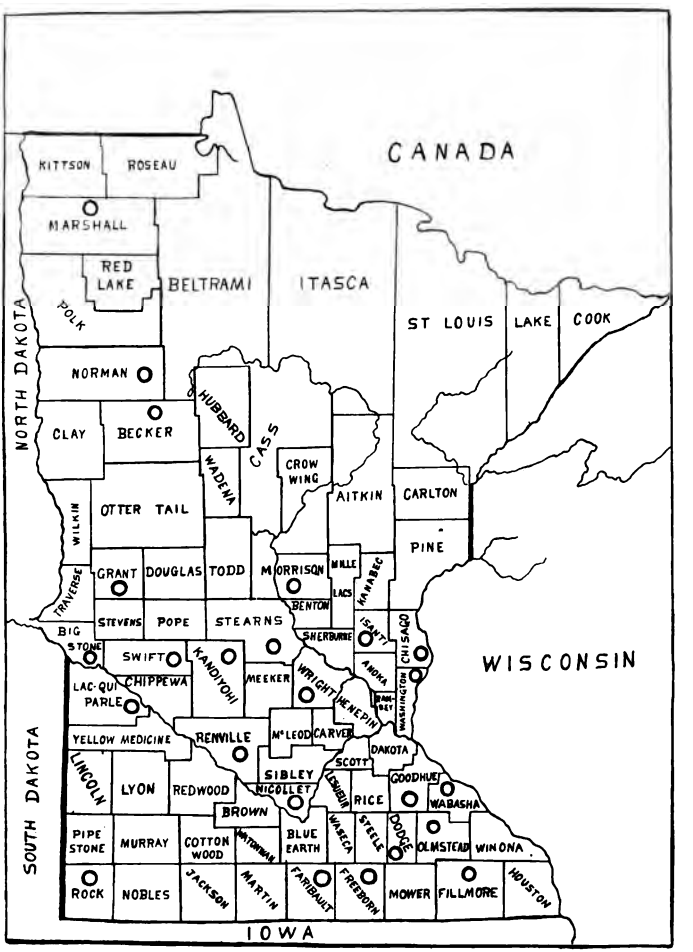


Fig. 123½.—Map of Minnesota. Correspondents are located in those counties which are marked with a O. See page 121.

ing willows and other trees in New Jersey; in 1895 it was found by Fernald at Melrose, Massachusetts, feeding in large numbers on willows. In "Garden and Forest," Vol. X, 1897, there is a statement to the effect that it was affecting all species of willows in the

Arnold Arboretum, and that it had been known about Boston and Cambridge for many years, and Vol. VIII of Psyche, 1899, states that it was very abundant about Boston in 1896. In 1898 and 1899 it became so injurious to Balm of Gilead Poplar and Willows in Massachusetts as to seriously threaten the business of nurserymen in these particulars. A report reaches us of the finding of one specimen in Montana in 1899, but this report lacks confirmation. A few years ago Burgess found it in Ohio. Dr. Howard reports receiving half-grown larvæ this summer from Detroit, Michigan. The above, with the specimens which we received from Bowbells in the northwestern part of North Dakota, indicate the westward march of this unwelcome foreigner.

Unfortunately, from the nature of the work of this insect, which is not very evident until the resulting injury is seen, most remedies or means of prevention are of but little avail; nevertheless something can be done in alleviation, and in view of its recent introduction into this part of the Northwest, radical measures should be resorted to in order to prevent such a destructive insect getting a foothold in this state.

Eleanor Ormerod, in her report of 1899, advised her constituents in England, where, by the way, the beetle has been known for a long time as "The Mottled Willow Beetle," to apply repellant washes to the trunks and branches of young trees, also to jar the trees, and the destruction of infested branches in the spring.

The writer has recommended the examination of nursery stock and young door-yard trees in June, if the presence of this pest is suspected, and the cutting off of the affected branches (or affected trunk if it is a small tree) and burning the same with the culprit inside. A possibly good preventive to young stock in the nursery or elsewhere would be a whitewash on trunks and larger branches, containing a liberal allowance of Paris green, applied two or three times during May and early June, and again, since egg-laying has been observed in the fall, in September. Jarring the trees during these two months, May and June, in the morning, causing the beetles to drop on a sheet below, is also suggested. The Agricultural Department recommends putting newspapers about the bases of trees, and above these, deterrent washes. Two parasites have been bred from this pest; an Ichneumon Fly, *Ephialtes irritator*, Fab., and *Ermogastra hartii*, Ashm.

The case has assumed such a serious aspect that this Department has notified all nurserymen who apply for State Certificates that hereafter no certificate will be granted to any nursery upon whose trees this beetle is found.

In addition to the works mentioned above, interesting accounts of this beetle can be found in "Loudon's Arboretum et Fructicetum," Vol. III, 1838; in Selby's "Forest Trees," 1842; in "Zeitschrift fur das Forst und Jagd-wesen," Vol. XXIII, 1891; in Westwood's "Introduction to Classification of Insects," Vol. 1; in "Lehrbuch der Mitteleuropäischen Forstinsekten Kunde," Vol. 1, by Judeith & Nitsche, 1895; in "Entomologica Americana," Vol. III, p. 123, 1897; in "Forest Protection," by W. R. Fisher; in "Forst-Zoologie," by Altum, Vol. III, Insekten, pt. 1; in Henschel's "Die Schadlichenfurst und Obstbaum Insekten;" in Journal of Columbus Horticultural Society, Vol. XVI; in 32nd Annual Report, Entomological Society of Ontario, 1902; in Bulletin No. 46, Bureau of Forestry, U. S. Dept. of Agriculture, 1904, entitled "The Basket Willow," and elsewhere. Many of the writers on this insect mention a habit it has of emitting a squeaking noise when handled or annoyed, evidently made by rubbing parts of the thorax together.

NURSERY INSPECTION.

The nurseries of the state which have applied for inspection have been found free from dangerous insects and contagious plant diseases, and, as a rule, appear to be in excellent condition in every respect. The nurserymen have, without exception, shown every disposition to assist the Entomologist in his work, and have been uniformly kind and courteous.

Since the discovery of the imported Mottled Willow and Poplar Borer, notice has been sent all nurserymen that hereafter no certificate will be granted if this dangerous pest is found in their stock.

Appended is a list showing the source of money ($130.18) obtained from inspection in accordance with the law, and also the fact that the same has been handed to the State Treasurer to be added to the fund for combating injurious insects in Minnesota.

F. L. WASHBURN, IN ACCOUNT WITH STATE AND NURSERIES.

Debit by Cash Received.

1904.	Name and Town.	No. of Cert.	Cash.
July 5.	Minnesota Seed Co., Faribault	27	$1.25
July 5.	Brand Nursery, Faribault	28	1.25
July 5.	Andrews Nursery, Faribault	29	1.25
July 6.	Clinton Falls Nursery Co., Owatonna	30	
July 6.	Mitchell Nursery Co., Owatonna	31	
July 6.	Minnesota State Nursery Co., Albert Lea	32	
July 7.	Albert Lea Nursery Co., Albert Lea	33	
July 8.	Wedge Nursery Co., Albert Lea	34	
July 9.	Winnebago Nursery, Winnebago City	35	47.59
July 9.	Fairmont Nursery, Fairmont	36	
July 10.	Amber Lake Nursery, Amber Lake	37	
July 12.	Kanaranzi Nursery, Kanaranzi	38	
July 12.	Luverne Nursery, Luverne	39	
July 21.	John Osborn, Dassel	40	2.00
July 22.	J. W. Beckman, Cokato	41	1.72
July 22.	John Eklof, Cokato	42	1.72
July 22.	W. H. Eddy, Howard Lake	43	1.72
July 22.	W. L. Taylor, Howard Lake	44	1.72
July 22.	D. M. Bowers, Howard Lake	45	1.72
July 28.	Jewell Nursery Co., Lake City	48	3.00
July 29.	County Line Fruit Farm, Lake City	49	3.75
July 29.	Pleasant Valley Fruit Farm, Pleasant Valley	50	4.50
July 29.	Vinegar Hill, Houston	51	6.50
July 29.	Preston Nursery, Preston	52	5.31
July 30.	Spring Valley Nursery	53	4.98
July 30.	A. O. Hawkins, Excelsior	46	1.55
July 30.	Chas. Hawkinson, Excelsior	47	1.55
Aug. 15.	John Hawkins, Minneapolis	54	1.50
Aug. 17.	Fred Cowles, West Concord	55	3.50
Aug. 17.	W. E. Fryer, Mantorville	56	3.50
Aug. 18.	G. W. Strand, Taylor's Falls	57	5.00
Aug. 24.	F. E. Cutting, Byron	58	5.00
Aug. 29.	John Zeller (New Ulm Nursery), New Ulm	59	4.25
Aug. 29.	Wm. Pfaender, Jr. (Pioneer Nursery), New Ulm	60	4.25
Sept. 3.	Mayfield Nursery, Lakeland	61	5.40
Sept. 3.	L. L. May & Co., St. Paul	62	
Sept. 12.	Hoyt Plant & Seed Co., St. Paul	63	1.00
Sept. 14.	Hennepin County Nursery, Eden Prairie	64	3.70
Total			$130.18

Credit by Cash Paid State Treasurer.

November	$130.18

REPORTS OF CORRESPONDENTS.

(See map on page 117.)

NAME AND LOCATION.	MAY.	JUNE.	JULY.	AUGUST.
Abrahamson, O. E., Buffalo Lake, Renville Co.	No insects.	Cut worms scarce; striped cucumber beetles abundant; currant worms plentiful; potato bugs abundant.	Minimum temperature 57; squash bugs (?) plentiful.	No chinch bugs observed; crickets numerous; plant lice on corn stalks; grub worms and cut worms noticed occasionally; rust took half crop.
Cook, S. Ray, Fort Ripley, Morrison Co.	No report.	Cut worms damaged corn considerably; currant worms damaged one-third of crop; plum leaf aphis and plum pocket found; potato beetles troublesome; plant lice on rose bushes.	Hessian fly reported but scarce.	No insect damage.
Emerson, Rudolph, West Concord, Dodge Co.	No chinch bugs; no potato bugs as yet.	Currant worm bad; potato bugs scarce; cucumber beetle quite numerous.	Potato bug and cabbageworm bad; latter just started.	Rust worse than all insects, 30 per cent loss; Minn. 169 not injured at all; fife next and bluestem injured worst of all; chinch bugs and Hessian fly not seen at all during season; cabbage worm bad; also potato bug.
Foss, Oluf N., Wendell, Grant Co.	No injurious insects, not even cut worms.	A few potato bugs.	Few potato bugs.	Wheat louse present; rust very bad; almost entire crop destroyed.
Graham, R. M., Rochester, Olmsted Co.	A very few chinch bugs; potato bugs few; tent caterpillars few.	Potato bugs numerous; smut on barley bad; rust on wheat not very bad; no chinch bugs.	No damage by chinch bug; potato bugs bad; elm-leaf louse plentiful.	Plum gouger damaged 25 per cent of plums; potato bugs very numerous; fire blight bad on young trees.
Hjelle, Ole, West Valley, Marshall Co.	No insect damage.	Potato bugs bad.	Hessian fly bad in wheat; potato bugs quite bad.	Hessian fly some damage; frit fly (?) bad; rust damaged 60 per cent of crop.
Holmberg, Ruth, Renville, Renville Co.	.....	.....	Potato bug worst pest; Hessian fly begun.	Hessian fly did little damage; potato bugs bad: cut worms numerous during first of summer.
Horton, T. J., North Branch, Chisago Co.	Chinch bugs; a carabid beetle, *Glopinus incrassatus*, Lec, found eating planted corn.	Potato beetle and cut worms numerous.	No insects.	No sign of chinch bugs.
Jensen, Andrew, Kanaranzi, Rock Co.	Wire worms bad on corn.	White grub bad; elm aphis abundant on shade trees.	.....	Hessian fly did some damage, but not much.

REPORTS OF CORRESPONDENTS—Continued.

NAME AND LOCATION.	MAY.	JUNE.	JULY.	AUGUST.
Larson, Albert, Goodhue, Goodhue Co.....	Few chinch bugs seen.	No damage by insects; only a few potato bugs.	Currant worms numerous; a few chinch bugs noticed; potato bugs numerous.	Cabbage worms present.
Ley, Lizzie L., Kellogg, Wabasha Co.....	No damage by insects.	Cucumber beetles and white striped (?) beetles numerous.	Potato bugs bad.	Potato bugs bad; grub worm damaged strawberry roots.
McKenzie, Wm., Willmar, Kandiyohi Co.....	Gophers numerous.	No insect damage.	Potato bugs destructive; smut and rust not damaging grain much.	Rust damaged wheat and oats badly; smut bad in barley, oats and wheat.
Moore, Chas. E., Detroit, Becker Co.....	Cabbage butterflies numerous; cut worms present and bad.	No sign of Hessian fly and chinch bug; sphinx caterpillar worked on clematis, etc.; potato bugs very numerous; plum gouger bad; plum pocket very bad; strawberry weevil (?) abundant.	Rust bad on wheat and oats; leaf rollers present; borer on boxelders; willow slug on golden willow.	Rust very bad.
Moore, O. W., Spring Valley, Fillmore Co.....	No trace of chinch bugs.	Chinch bugs present in limited numbers; potato beetles present; currant worms numerous; curculio bad; plum pocket serious.	No damage from chinch bugs; potato bugs worse than ever; pum curculio on apple serious; leaf hopper bad; codling moth at work; aphis scarce.	Cabbage worm active; insects same as mentioned for July; rot of potatoes bad.
Nelson, Chas. F., Braham, Isanti Co.....	Cut worms, quite a few.	Currant worms bad; potato bugs numerous.	No Hessian fly nor chinch bug; potato bugs very numerous; oak leaf badly affected with leaf miner (?).	Red-humped apple tree caterpillars quite numerous.
Newland, John G., Hendrum, Norman Co.....	Pocket gophers bad; no insects.	Potato bugs bad; worms eating into wheat kernels; cut worms numerous.	Lice on plum trees; rust bad on wheat; 20 per cent loss.	Some grain plant lice; no damage.
Olson, Chester, Adelaide, Big Stone Co.....	Cut worms present; tent caterpillars found; boxelders bothered with white worms (?) rolling leaves.	Small white (?) worm (sawfly) on ash leaves; Hessian fly is not noticeable; potato bugs not as troublesome as in 1903.	Effects of Hessian fly noticed on 24th; less than 5 per cent of wheat and rye damaged; potato bugs bad; slight damage from cabbage worm.	Hessian fly scarcely noticeable; rust damaged 50 per cent of wheat; crickets and grasshoppers extremely scarce; no boxelder bugs; potato bugs as bad as ever; cut worms did little damage.
Orton, Geo. E., Marietta, Lac qui Parle Co.....	Cut worms plentiful; tent caterpillars numerous; plum leaf galls (?) bad; boxelder galls.	Plum pocket plentiful; boxelder not badly damaged.	Hessian fly not very bad; rust bad; fire blight present.	.....

REPORTS OF CORRESPONDENTS—Concluded.

NAME AND LOCATION.	MAY.	JUNE.	JULY.	AUGUST.
Pederson, P. A., Town of Lorning, Swift Co..... Beardsley, Big Stone Co.....	Tent caterpillars present.	Ash tree leaves eaten; also oak leaves (Big Stone Co.).	Rust present; no ash tree insects (Swift Co.).	Rust worst enemy; Hessian fly only once found; crickets not numerous as in former years; potato bugs bad (Swift Co.).
Roach, S. Z., New Paynesville, Stearns Co.....	Grubs thick in fields; cut worms doing some damage.	Potato bugs very thick; currant worms very troublesome; chinch bugs in wheat.	Chinch bugs did no damage.	Rust bad; chinch bugs did some damage in one field; potato rot present.
Swenson, Edw., Scandia, Washington Co.....	Worms on fruit trees.	Plum pocket found; cockscomb gall on elm leaves; fall web worm (?) attacking leaves of bush. Joint worm or cut worm on timothy; lice on poplar (July 12); canker worm on cherry trees; greenish white worm enclosed at ends of branches of cherry and apple trees (leaf roller); currant worm; yellow checked caterpillar noticed; plant lice on elm and boxelder; potato bug present, not much damage done.	Army worm on timothy; cabbage worm; leaf hopper on apple tree; lice on apple trees; potato bugs bad.	.....
Washburn, Edson, Monticello, Wright Co.....	Chinch bugs few; few eggs of tent caterpillar.	No work of Hessian fly nor chinch bug; fire blight bad; few grasshoppers; no tent caterpillars; potato bugs plentiful.	Potato beetles; chinch bug present; tiny white worm one-eighth inch (frit fly ?) in wheat.	Chinch bugs scarce; no tent caterpillars.
Wedge, Robert C., Albert Lea, Freeborn Co.....	Lice on plum trees; strawberry leaf insect; galls on boxelder.	Leaf-hopper and lice on apple and plum trees in nursery; also same on ash in nursery.	.....	.....
Woolery, Roy, Blue Earth, Faribault Co.....	No insect damage.	Cut worms at work in corn; 2 to 5 per cent damage.	Potato bugs doing no damage; no worms on the trees.	.....

IDENTIFICATION OF INSECTS.

Some of the principal inquiries regarding insects received through the mail during the past year are here listed. Plant lice began to be heard from early in May, and wire worms, the larvæ of "Click Beetles," evidently caused trouble in May and June. Cut worms, beginning their depredations about the middle of June, were heard from through the summer as late as August 6th. The cabbage root maggot was the cause of numerous letters from June 10th; and from August 12th to September 7th we had our usual quota of green cabbage worms. About the middle of August some complaints of grain plant lice in wheat reached us, but this insect caused no special injury. Complaints of Cottony Maple Scale, which has been very abundant this summer, reached us through the mail from Hennepin, Ramsey and Cottonwood counties, besides being observed by the writer in Rock county. The Chinch Bug and Hessian Fly, the reader will observe, are this year conspicuous for their absence though mentioned in one or two instances. We append a map of the state showing the counties. From one to several inquiries came from each county marked by an X.

DATE.	COUNTY.	INSECTS IDENTIFIED.	HOST PLANTS, ETC.
Mar. 7	Ramsey	Buffalo Moth, *A. scrophulariæ*—Linn	Woolens.
Mar. ..	Hennepin	Mites, *Tyroglyphus longior*—Gervais	Flour mill.
Mar. 17	Hennepin	Staphylinid	Supposed by correspondent to injure radishes.
Mar. 18	Hennepin	Apple Bark Louse, *M. pomorum*—Bouche	Lilac.
Mar. 30	Rice	Oyster-shell Bark Louse, *M. pomorum*—Bouche	Transcendent Crab.
Apr. 6	Brown	Scurfy Bark Louse, *Chionaspis furfurus*—Sign	Apple tree.
Apr. 21	Wilkin	Cecropia Moth, *Attacus cecropia*—Linn	Cocoon.
May 3	Hennepin	Plant Lice	No specimens.
May 6	Stearns	Lachnosterna	Corn fields. No specimen.
May 6	Goodhue	Scurfy Bark Louse, *Chionaspis furfurus*—Sign	.....
May 10	Rice	Lecanium	Oleander.
		Aleurodes	Potted Plants.
May 16	Douglas	Lice, *Aphis mali*—Fab.	Apple.
May 16	Ramsey	Wire Worms	Asparagus.
May 17	Renville	Scolytid borers, also Atænius	.....
May 20	Dodge	Cattle Louse, *T. scalaris*—Nitzsch	Live Stock.
May 21	Becker	White Scale, *Aspidiotus nerii*	Oleander.
May 21	Ramsey	Wire Worm	Asparagus.

DATE.	COUNTY.	INSECTS IDENTIFIED.	HOST PLANTS, ETC.
May 23	Becker	Wire Worm	Wheat.
May 26	Ramsey	Scales	Box elder. No specimen.
May 27	Wadena	Wire Worms	Wheat.
May 27	Big Stone	Canker Worm	Box elder.
May 31	Hennepin	Cut Worms	Tomatoes.
May 31	Dakota	"Squash Bugs"	No specimen.
May 31	Redwood	Striped Cottonwood Beetle, *Melasoma scripta*—Fabr	Poplar.
June ..	Isanti	*Glopinus incrassatus*	Kernels of planted corn.
June 4	Renville	Wire Worms	Corn.
		March Flies, *Bibio albi pennis*..	.....
		Apple Aphis, *A. mali*.—Fabr...	.....
		Buffalo Tree Hopper, *C. bubalus* —Fabr	.....
June 9	Hennepin	Cut Worms	.....
June 9	Hennepin	Flies	Cattle. No specimen.
June 9	Lac qui Parle	Flies	Cattle. No specimen.
June 9	Lac qui Parle	Gall-making Plant Louse	Plum.
June 9	Dakota	Gall-making Plant Louse	Plum.
June 10	Hennepin	Lecanium	Elm.
June 10	Hennepin	Cabbage Maggot, *P. brassicæ*	.....
June 10	Dakota	Gall-making Plant Lice	.....
June 10	Polk	Cut Worms	No specimens.
June 13	Dakota	Squash Bugs, *A. tristis*—De Geer	.....
June 14	Hennepin	Cabbage Maggot, *P. brassicæ*	.....
June 15	Otter Tail	Elm Aphis, *Sch. americana* - Riley	Elm.
June 16	Rice	Galls	Plum Leaf.
June 17	Renville	Galls	Plums.
June 17	Hubbard	Wire Worm	.....
June 18	Hennepin	Cut Worms	Tomatoes.
June 18	Hennepin	Ants	Remedies for, on lawn.
June 19	Martin	Rose Pests	.....
June 20	Douglas	Ants	Lawn.
June 21	Hennepin	Lice	Honey suckle.
		Rose Slug	Roses. No specimen.
June 21	Hennepin	White Grubs, *Lachnosterna*	Ginseng.
June 21	Ramsey	Cabbage Maggot, *P. brassicæ*	Cabbage.
June 21	Freeborn	Climbing Cut Worm	Apple.
June 24	Hennepin	Cabbage Maggot, *P. brassicæ*	Cauliflower.
June 24	Ramsey	Grubs, *Lachnosterna rugosa*—Welsh	Lawn.
		Cut Worms	Peas.
June 25	Rice	Ants	Lawn.
June 27	Pine	Apple-tree Borer	No specimen.
June 29	.....	Plum Pocket	Plum leaves.
July 1	Hennepin	Mites, *Tyroglyphus longior* and *Aleurodes farinata*	.....
July ..	Hennepin	Fleas	Wheat in mill.
July ..	Freeborn	Plum Curculio, *C. nenuphar*	Apple, 100 per cent of fruit destroyed.
July 10	Chicago, Ill	Leaf-cutting Bee, *M. brevis*—Say.	Roses.
July 12	Washington	Plum Pocket	Plums.
		Cockscomb Gall, *C. ulmicola*—Fitch	Elm.
		Lice	Poplar. No specimens.
July 13	Blue Earth	Luna Moth, *A. luna*—Linn	.....
July 13	St. Louis	Ephemerids	.....
July 14	Lyon	Gall-making Plant Lice	.....
July 15	Hennepin	Bumble-flower Beetle, *Euphoria inda*—Linn	Apple.
July 15	Hennepin	Unicorn prominent, *S. unicornis* —S. & A.	.....
July 15	Ramsey	Stalk Borer, *Gortyna nitela*—Gu.	Tomatoes.
July 18	Rice	Lice (eggs)	Old eggs in fur.
July 18	Waseca	Stalk Borer, *Gortyna nitela*—Gu.	.....
July 21	Hennepin	Stalk Borer, *G. nitela*—Gu	Aster.

DATE.	COUNTY.	INSECTS IDENTIFIED.	HOST PLANTS, ETC.
July 21	Blue Earth	Stalk Borer, *Hydræcia (gortyna) nitela*	Dahlia.
July 22	Ramsey	Maple Scale, *P. innumerabilis*—Rathv.	.....
July 22	Goodhue	Grain Plant Lice	Wheat.
July 22	Traverse	Grain Plant Lice	Wheat.
July 25	Mower	Grain Plant Lice	Grain.
July 28	Winona	Pear and Cherry Slug, *S. cerasi*—Peck	Cherry.
July 28	Hennepin	Horned Corydalis, *Corydalis cornuta*	.....
Aug. 1	Fillmore	Med. Flour Moth, *E. kuehinella*—Zell	Flour Mill.
Aug. 1	Blue Earth	Melon Louse, *A. cucumeris*—Forbes	Melons.
Aug. 2	Montreal, Canada	"Death Watch," *S. panicea*—Linn	Flour on shipboard.
Aug. 2	Ramsey	Apple Aphis, *A. mali*—Fabr.	Apple.
Aug. 2	Hennepin	Apple Aphis, *A. mali*—Fabr.	Apple.
Aug. 2	Hennepin	Maple Scale, *P. innumerabilis*—Rathv.	Elm.
Aug. 3	Hennepin	Lice	Wheat.
Aug. 3	Grant	*Chrysochus auratus*	"Shoe String Plant."
Aug. 5	Washington	Grain Plant Lice	Wheat.
Aug. 6	Otter Tail	Grain Plant Lice	Wheat.
Aug. 6	Hennepin	Lecanium	Elm.
Aug. 6	Polk	Cut Worms	Pasture.
Aug. 10	St. Louis	Scab	Apple Leaves.
Aug. 11	Nobles	Exotic Ant	Bundle of Bananas.
Aug. 12	Mille Lacs	Plant Lice	.....
Aug. 12	Lac qui Parle	Grain Plant Lice	Wheat.
Aug. 12	Beltrami	Cabbage Worms, *P. rapæ*—Linn.	.....
Aug. 15	Dodge	Apple Aphis, *A. mali*—Fabr.	Apple.
Aug. 16	Red Lake	Grain Plant Lice	Wheat.
Aug. 18	Polk	Grain Plant Lice	Wheat.
Aug. 19	Lyon	Cabbage Worm, *P. rapæ*—Linn.	Rape.
Aug. 20	Kandiyohi	Grain Weevil, *Calandra granaria*	Wheat in bins.
Aug. 26	Cass	Grain Plant Lice	Wheat.
Aug. 27	Otter Tail	Galls	Willow.
Aug. 27	.....	Galls	White willow leaf.
Aug. 30	Steele	*Coptocyla clavata*—Fabr.	Supposed by correspondents to be injuring wheat.
Sept. 1	North Dakota	Willow and Poplar Borer, *Cryptorhyncus lapathi*—Linn.	Carolina poplar.
Sept. 1	Isanti	Red-humped Apple Tree Caterpillar, *Oedemasia concinna*—Sm. & Abb.	.....
Sept. 7	Hennepin	Cabbage Worm, *Pieri rapæ*	Horse radish.
Sept. 7	Kandiyohi	Flies	Stock. No specimens.
Sept. 15	Hennepin	Bumble Flower Beetle, *Euphoria inda*	Apple Orchard.
Sept. 15	Hennepin	Unicorn prominent, *C. unicornis*	.....
Sept. 17	Ramsey	*Diplosis violicola*—Sm. & Abb.	Violet.
Sept. 26	Kandiyohi	Currant Lice, *Aphis ribis*—Linn.	Currants.
		Plum Aphis, *Aphis prunifolii*—Fitch	Plum.
		Apple Aphis, *Aphis mali*—Fabr.	Apple.
		"Lady Bird"	.....
Sept. 29	Ramsey	"Walking Stick"	.....
Oct. 3	Nicollet	Cercropia Moth, *Attacus cecropia*	Cocoon.
Oct. 6	Hennepin	Garden Spider, *Epeira*	.....
.....	Marshall	Oleander Scale	Oleander.
.....	Ramsey	Melon Lice, *Aphis cucumeris*	Cucumber.
Oct. 12	Rock	Zebra Caterpillar, *M. picta*	Tamarack.
Oct. 12	Becker	Bumble-flower Beetle, *Euphoria inda*	Carnations in greenhouse.
Oct. 17	Cottonwood	Maple Scale, *Pulvinaria innumerabilis*	Soft maple.

DATE.	COUNTY.	INSECTS IDENTIFIED.	HOST PLANTS, ETC.
.....	Morrison.....	Mites, *Aleurobius farinæ*—De Geer	In screenings.
Oct. 22	Ramsey.....	"Water Boatmen," *Corisa*.....	"Swarming by thousands in St. Paul on sunshiny afternoon, Oct. 12, between 2 and 3."
Oct. 28	Nicollet.....	Plant Bugs, *Trapezonotus*.....	Supposed by correspondent to be Chinch Bugs.
Nov. 4	St. Louis.....	Slugs, *Limacidæ*.....	Plants in garden.
Nov. 14	Hennepin.....	Ants, *Monomorium pharaonis*—Linn	In house.
Nov. 16	Dodge.....	Scurfy Scale, *Chionaspis furfurus*	Apple.
Nov. 25	McLeod.....	Rabbit Bot, *Cuterebra*.....	Rabbit.

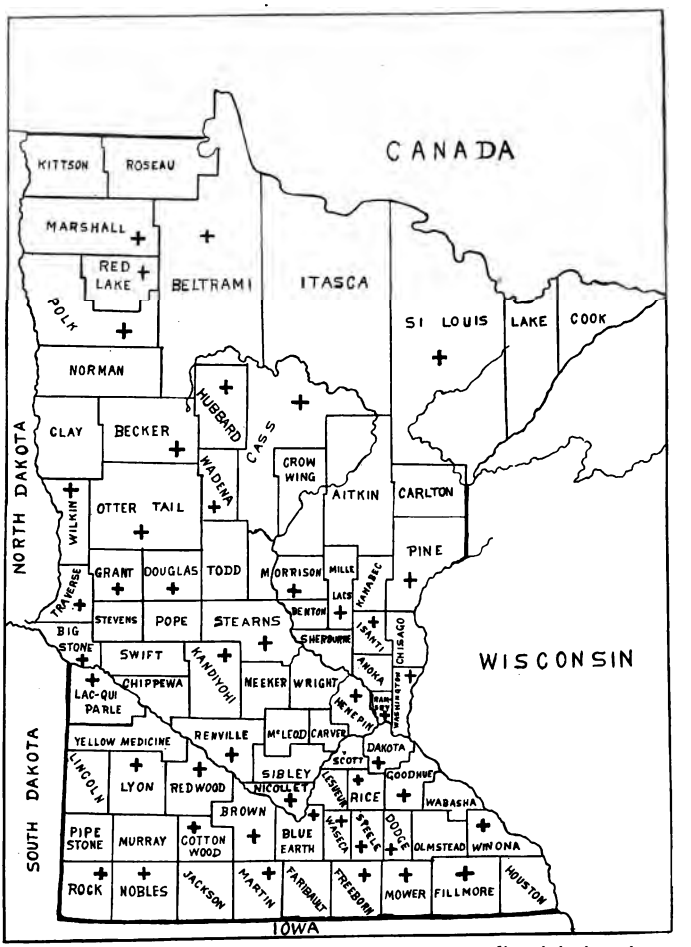


Fig. 123¼.—Map of Minnesota. Inquiries, one or more, regarding injurious insects, season of 1904, received from counties marked with a +.

A PLEA FOR SOME OF OUR COMMON BIRDS BASED UPON THEIR FOOD HABITS.

There appears to be a call for information regarding the food habits of some of our common birds, which are often condemned because of ignorance upon this point. In an endeavor to furnish this information and describe briefly some of our feathered friends in such a way that they may be recognized, Press Bulletin No. 19 has been issued. Largely at the instigation of the Audubon Society of Minnesota, a strong effort is being made to inculcate in our citizens, particularly in the school children, a love for the birds, which will check the cruel practice of shooting and maiming, with sling-shot or air gun, animals which are as capable of suffering acute pain as ourselves. However injurious a bird may be—and there are some which at times do work injury upon the farmer or fruit grower—this is nevertheless no excuse for its being caused to suffer at the hands of a thoughtless boy, who, in years after, will regret his cruelty. With this educational object in view the efforts of the Audubon Society are being ably seconded by the State Horticultural Society and the State Educational Association. These societies have appointed from among their members a committee to forward this work. Particulars regarding the work can be obtained from any one of the following members of the committee: Prof. Lange, Central High School, St. Paul; Pro. O. T. Denny, Central High School, St. Paul; Mrs. J. B. Hudson, Lake City; Mrs. La Penotiere, 1928 Portland Avenue, Minneapolis; Mrs. Ida Thompson, Duluth; Mr. S. A. Stockwell, Penn. Ins. Co., Andrus Building, Minneapolis; Miss Sarah L. Putnam, 229 Eighth avenue S. E., Minneapolis; Prof. A. W. Rankin, Minneapolis; F. L. Washburn, State Experiment Station, St. Anthony Park.

The State Experiment Station is only too glad to assist in this good work by publishing at this time the following economic data on the food habits of some of our common birds. These data are largely the result of the work done by the United States Department of Agriculture and by independent workers, credit for which is given in the text. The writer desires to urge upon the teachers the need of encouraging their pupils in humanitarian principles in connection with our birds, and discouraging the stoning of the same,

the robbing or destruction of nests, or the maiming of such helpless animals. These acts are, for the most part, punishable by law, but if a child can be led into the observance of these laws through intelligent interest in the birds themselves, the result is better than if fear is the instigating cause. Upon adults we would urge the desirability of discriminating in judging birds, the careful study of the food habits before condemning, in the building of boxes for wrens, bluebirds and martins, and in encouraging by their example generally a wise and humane policy toward our feathered associates.

Dudley Dorn rightly says: "No one should own or handle a gun unless first proved to be possessed of common sense."

BLUEBIRD.

Fig. 124.—Bluebird. From Biological Survey U. S. Dep. of Agriculture.

Upper parts, including wings and tail, bright blue; breast, throat and sides, reddish. Length, seven inches. A description of this common bird is hardly necessary. It is of wide distribution, from the Atlantic to the Rockies, and from Canada to the Gulf of Mexico. Its note is among the first to be heard in the spring, and one of the last in the fall, at which latter time we associate it with the falling leaves of Indian summer. To the writer its note in the fall has always appeared to take on additional sadness, as though lamenting the dying of the year. It nests in hollow trees and boxes erected in suitable places, and should be encouraged by providing it with plenty of such

opportunities for housekeeping. An examination of two hundred and five stomachs showed that seventy-six per cent of the food consisted of insects and their allies, while twenty-four per cent is made up of vegetable substances. Beetles constitute twenty-eight per cent of the whole food, grasshoppers twenty-two, caterpillars eleven, and various insects, including spiders, comprise the remainder of diet. All these insects are more or less harmful, except a few predaceous beetles, which amount to eight per cent. Prof. S. A. Forbes of Illinois examined 108 specimens secured in every month except November and January, and results of these examinations prove that although the bluebird eats some insects which are beneficial, and occasionally takes a raspberry or gooseberry, it consumes such an immense number of injurious insects, cutworms and other insects, such as army worms, moths, grasshoppers and crickets, that it is undoubtedly a beneficial bird. Nestlings of the bluebird, like the young of almost all of our common birds, are fed an enormous quantity of insects.

PHOEBE.

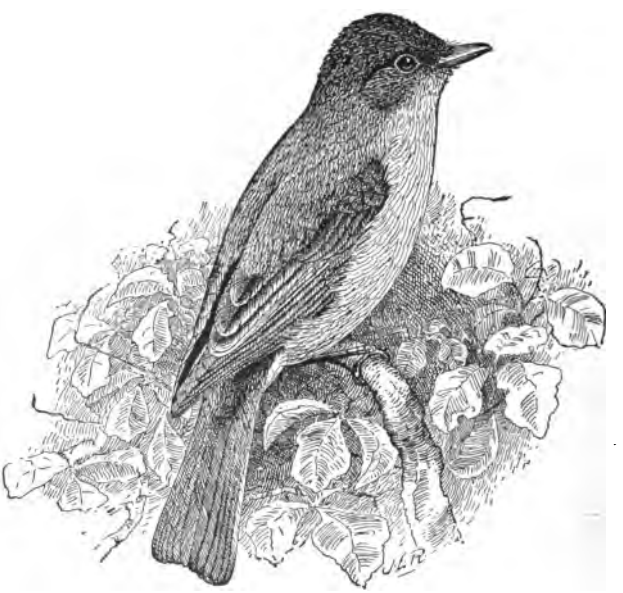


Fig. 125.—Phoebe. From Biological Survey U. S. Dept. of Agriculture.

Length about seven inches, upper parts grayish brown shaded with olive, top of head darker; outer edge of outer tail feathers white or yellowish, except at tip. Under parts white, more or less tinged with yellow; breast and sides brownish gray; bill black.

This familiar bird is one of the earliest arrivals in the spring, and generally first observed before the leaves appear on our trees, at which time its plaintive note, sounding like "pe-wee," with the accent on the last syllable, announces the arrival of spring. It is commonly found near buildings on the farm, and frequently builds its bulky nest of moss and mud on a beam in a shed or under a bridge. It is of wide distribution, being found throughout the United States east of the Plains, and is deservedly a great favorite. While it occasionally takes a raspberry or blackberry, or more commonly seeds of various kinds, and elderberries, wild cherries, etc., its principal food is insects; it is, in fact, a true fly catcher. Ninety-three per cent of the contents of eighty stomachs examined consisted of insects and spiders. Generally two broods are reared in a season.

HOUSE WREN.

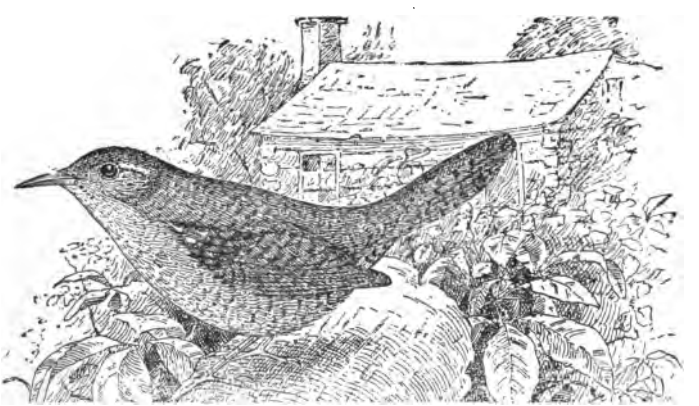


Fig. 126.—House Wren. From Biological Survey U. S. Dep. of Agriculture.

Cinnamon brown on back, marked indistinctly with black and white, becoming more reddish on rump and tail; tail rather long and marked with fine bars, black bars also showing on sides. Length five inches. This saucy bird is found over the entire United States,

nesting about buildings or in boxes or houses prepared for it by the thoughtful farmer. As in the case of the bluebird, it is well to give it every opportunity for nesting, since its food consists almost entirely of insects, and it will repay you for your friendship by searching out and devouring caterpillars in your shrubs and trees. It is said to raise several broods in a season. An examination of fifty-two stomachs by the United States Department of Agriculture showed that ninety-eight per cent of their contents were made up of insects and their near relatives, the remaining two per cent being vegetable matter, small bits of grass, etc., evidently taken with the insects by accident. One-half of the food consisted of grasshoppers and beetles; the remainder, caterpillars, bugs and spiders.

BARN SWALLOW.

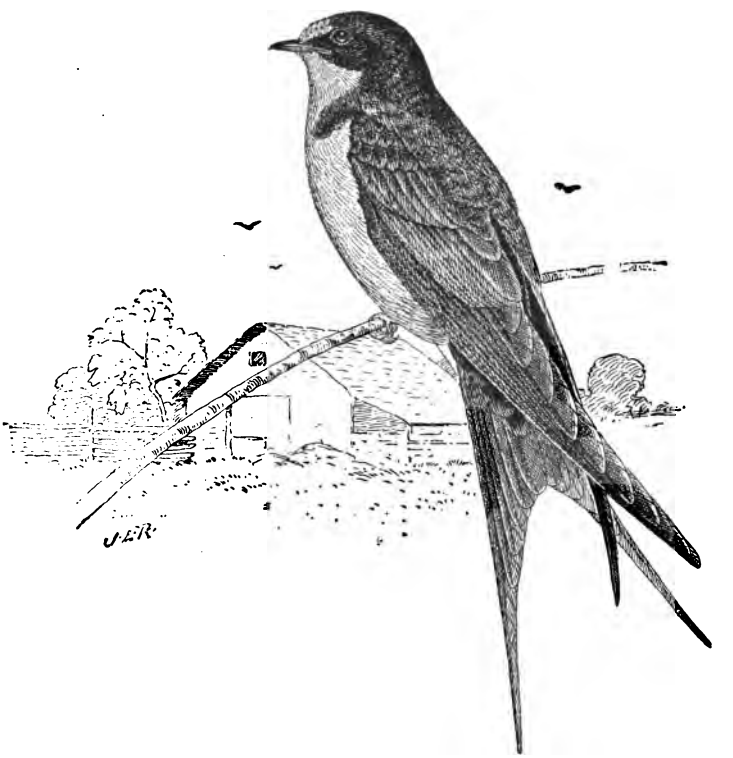


Fig. 127.—Barn Swallow. From Biological Survey U. S. Dep. of Agriculture.

Throat, forehead and breast reddish chestnut, paler below. Metallic blue on back and head. Tail forked; some white on each feather in tail except those in the middle. Nest of mud and grass lined with feathers, in barns and other buildings. In the writer's opinion no farm scene is complete without these birds flitting in and out of the barn. A rapid and graceful flyer, it captures, while on the wing, moths, flies, beetles and frequently grasshoppers and flying ants. Of three specimens shot in June in Nebraska, in a "locust year," according to Professor Aughey, the stomachs of two contained sixty-eight locusts and the stomach of the third thirty-seven locusts. As might be inferred, these birds are strictly insect eaters.

MEADOW LARK.

Fig. 128.—Meadow Lark. From Biological Survey U. S. Dep. of Agriculture.

The Meadow Lark is common from the Atlantic to the Great Plains, and a variety extends west of the Plains to the Pacific Coast. It is an inhabitant of both prairie land and fields in districts more or less wooded, and while not a fine songster, in the opinion of many, adds much to our enjoyment of the country. The color of the upper parts is a mingling of black, whitish and chestnut, darker on the head, where we find a light streak running back from the bill; side of head light, showing a yellow streak over and in front of eye; chin, throat

and breast bright yellow, with a jet black collar or cravat on breast in form of a crescent; all but the central tail feathers showing considerable white. Length, ten to eleven inches. It nests upon the ground, and seldom perches on trees. Analyses of stomach contents give interesting results: Two hundred and thirty-eight stomachs examined contained seventy-three per cent animal matter, and twenty-seven per cent vegetable, the latter being found in the winter. The animal food consisted of insects of the ground species—beetles, bugs, grasshoppers, caterpillars, and a few flies, wasps and spiders. A number of the stomachs were taken from birds killed when the ground was covered with snow, but still contained a large percentage of insects. Crickets and grasshoppers constitute twenty-nine per cent of the entire year's food, and sixty-nine per cent of the food in August. Twenty-one per cent of beetles was found, of which about one-third are predaceous ground beetles; the others all harmful species. In May caterpillars constitute over twenty-eight per cent of the whole food, with a large number of cutworms. Grain makes up fourteen per cent, and weed and other seeds twelve per cent.

VESPER SPARROW, VESPER BIRD, GRASS FINCH, BAY-WINGED BUNTING.

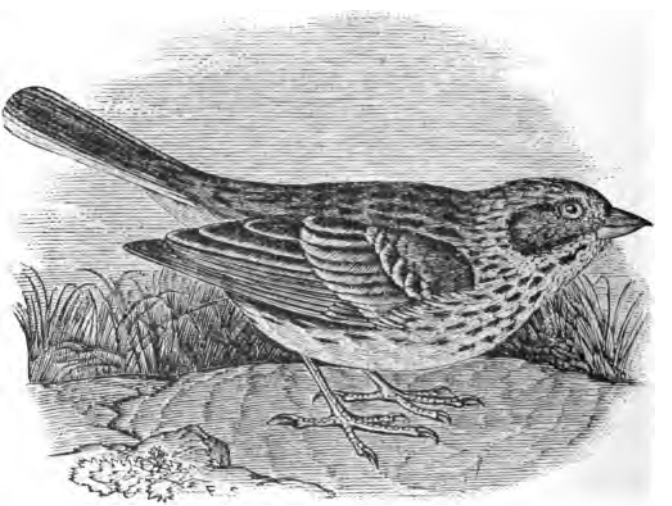


Fig. 129.—Vesper Sparrow. From Coues, "Key to North American Birds."

Like the Meadow Lark, a bird of the pasture, field and prairie. Frequently seen in the road, when it will run in front of you a distance before taking flight. At the latter time it always shows the white of its outer tail feathers, a most characteristic marking. The upper parts are brownish gray with more or less black and brownish black and brown streaks on sides and breast. Length, about six inches. Nests on the ground. This modest colored bird is quite a singer at times, its song reminding one somewhat of that of the Song Sparrow. About two-thirds of the year's food consists of seeds and other vegetable matter, the remainder consisting largely of cutworms, grasshoppers, army worms and spiders. Of thirty-seven Wisconsin adults studied by King, thirty-one had eaten various small weed seeds; five, four grasshoppers; one, eight grasshoppers' eggs; four, ten larvæ; fourteen, twenty-seven small beetles; three, eight moths; one, three flies; one, three land-snails; one, two kernels of wheat; one, a kernel of rye.

CHICADEE, BLACK-CAPPED TITMOUSE.

Fig. 130.—Chickadee. Original.

Dear to us because of its cheerful activity in the cold of winter when almost all other bird friends have left us. From an economic standpoint a great benefactor, for not only does it consume large

numbers of insects in summer, but more than one-half the winter food consists of insects and their eggs. The eggs of plant lice make up one-fifth of the entire food, in fact the destruction of these eggs on fruit and shade trees is the chief beneficial work of this bird in the winter, and the good it does in this way must not be under-estimated. Examinations of stomachs or crops of these birds has shown that sometimes more than four hundred and fifty eggs of plant lice are consumed by one bird in one day. Eggs of canker worms and tent caterpillars are also eaten. Four stomachs or crops examined showed, as the result of a single day's feed, one thousand and twenty-eight eggs of canker worms. Four others contained about six hundred eggs of canker worms and a hundred and five mature female canker worms. Surely if any bird deserves protection, it is this one. Such a familiar bird hardly calls for a description. Head, back of neck and throat black; sides of head and neck whitish; breast white; sides washed with brownish yellow. Length about five and one-half inches. Nests in old stumps and decayed trees, preferably birch; holes not far from ground generally. In addition to its cheerful "chic-a-dee-dee" it has a number of other notes, some of them extremely musical.

DOWNY WOODPECKER.

A true benefactor in that its food consists almost entirely of injurious insects, and it is with us both winter and summer. It is the smallest of our Woodpeckers, being only six and four-fifths inches long. Black above; a scarlet band on back of neck; white on middle of back; under part white; central feathers of tail black; the outer ones white with black markings; wings black spotted with white. The female lacks the scarlet patch on back of neck. It nests in holes in trees. Often seen in winter in company with Nuthatches, Chickadees and Brown Creepers. What little vegetable food it eats consists of seeds of poison ivy, sumac, etc. Seventeen Wisconsin specimens had eaten forty insect larvæ, twenty wood-boring grubs, three caterpillars, seven ants, four beetles, a chrysalid, one hundred

and ten small bugs, a spider, with a few acorns, small seeds and a little woody fibre apparently taken by accident with the grubs. Three-fourths of the food of one hundred and forty specimens examined by the Department of Agriculture consisted of insects. Nearly one-fourth consisted of ants, chiefly from those which were caring for plant lice, or burrowing in wood.

Fig. 131.—Downy Woodpecker. Original.

FLICKER, GOLDEN-WINGED WOODPECKER, PIGEON WOODPECKER, YELLOWHAMMER, HIGH HOLE.

Top of head ashy; band across back of head scarlet; back olive brown conspicuously barred with black; rump white; tail feathers above black, with white markings tinged slightly with yellow, and

with yellow shafts; black spot on side of throat under eye; side of head and throat dove color, black crescent on breast; lower breast and under parts white, more or less washed with light brown, and marked with large, round, black dots; tail beneath yellow; long feathers of wing yellow below, and with yellow shafts. The female lacks the streak or spot on the side of the throat. Length, twelve inches. Nests in holes in trees. This familiar bird, whose call we associate with the warm promising days of early spring, before the

Fig. 132.—Flicker. From Biological Survey U. S. Dep. of Agriculture.

leaves appear on the trees, differs from the other Woodpeckers in being something of a ground feeder. It eats wood-boring grubs, to be sure, but is very fond of ants, and is quite apt to be discovered dining on the ground before a large ant hill. Two stomachs examined contained over 3,000 ants each. The Flicker occasionally takes a little fruit.

THE NIGHTHAWK.

Fig. 133.—Nighthawk. After Brehm.

Back blackish, marked with whitish or cream; white bar on wings; tail blackish, forked; broad white band on throat and white band on tail of male; under parts barred with black and white. Nests on ground. But few who have walked in field and woods have not flushed this bird resting inconspicuously on ground or limb of a tree, and we are all familiar with its graceful evolutions in the air during afternoon and evening, where its rather harsh cry at once draws our attention. Frequently a bird closes its wings and drops swiftly, again soaring upward just before reaching the ground. At such times one hears a booming sound, something similar to the noise made by blowing across the large mouth of a bottle. Just how this is produced appears to be a matter of question among ornithologists. Some claim it is made by the air rushing through the stiff wing feathers, called primaries. The food of the Nighthawk appears to be May flies, dragon flies, beetles, certain water insects which fly in the evening, many bugs and grasshoppers. From seven specimens secured in Nebraska Professor Aughey took three hundred and forty-eight Rocky Mountain Locusts (one of our most injurious insects). In an Arkansas specimen F. L. Harvey found more than six hun-

dred insects—gnats, beetles, flies, ants and grasshoppers. Naturally a bird with habits like the Nighthawk would never injure fruit or berries. Some people confound the Nighthawk with the Whippoorwill, quite a different bird.

MARSH HAWK.

Fig. 134.—Marsh Hawks. After Ridgway, Bulletin No. 3, Division of Ornithology and Mammalogy U. S. Dep. of Agriculture.

Male and female quite different, both in size and color. Adult male nineteen inches long, grayish above, the tail being barred with blackish; feathers above at base of tail (upper tail coverts) conspicuously white; breast gray, fading into white on belly, where brownish markings are found. The adult female is twenty-two inches long, dark brown above, marked on head and neck with reddish brown; upper tail coverts as in male, conspicuously white; tail darker brown barred with reddish brown; breast buff, the color fading on belly. Nests on the ground in marshes. This is pre-eminently a bird of the meadows and prairies, and is often seen skimming over the top of the marsh grass hunting its food, at which time white of the upper tail coverts is conspicuous. It eats field mice, squirrels, rabbits, grasshoppers, frogs, reptiles, and occasionally small birds or poultry but not often. The writer regards it as a useful bird to the agriculturist. Out of one hundred and twenty-four stomachs examined by the United States Department of Agriculture, seven contained poultry or game birds; thirty-four contained other birds; fifty-seven contained mice; twenty-two contained other mammals; seven contained reptiles; two contained frogs; fourteen contained insects; the contents of one were undetermined, and eight were empty. Dr. B. H. Warren examined

fourteen stomachs with the following results: Seven had only field mice in their stomachs; three, frogs; two, small birds (warblers); one, a few feathers, apparently of a sparrow, and fragments of insects; one a large number of grasshoppers, with a small quantity of hair, evidently of a young rabbit.

SCREECH OWL.

Varies greatly in color from reddish or rufous to gray. In rufous specimens rufous above generally showing fine black lines. Below, whitish with feathers barred with reddish or rufous. Or, in grayish specimens, above brownish gray with faint black markings mingling with brown. Length about ten inches. This is a quite familiar bird about our orchards and barnyards, and, as its food habits show, its presence should be encouraged. Of two hundred and fifty-five stomachs examined under the direction of the United States Department of Agriculture, one contained poultry, thirty-eight contained other birds; ninety-one contained mice; eleven contained other mammals; one hundred contained insects; two contained lizards; four contained batrachians; one contained fish; five contained spiders; nine contained crawfish; seven contained miscellaneous matter; two contained scorpions; two contained earthworms; and forty-three were empty.

Fig. 135.—Screech Owls. After Plate 23, Bulletin No. 3, Division of Ornithology and Mammalogy U. S. Dep. of Agriculture.

From consideration of the food habits of the two above birds, representatives of the order of Hawks and Owls, it would seem that we make a mistake in wholly condemning this much maligned group, for among the hawks and owls we certainly find some in whom the good qualities seem to outweigh the bad.

THE ENGLISH SPARROW.

Fig. 136.

Our illustration is hardly needed, since this hardy and pugnacious bird has fought his way into every town and village of any size in Minnesota. He is welcomed by some, possibly, on account of his cheerful chirpings in winter when other birds have left us, but disliked by the majority not only because he defiles buildings and walks, and by his persistence in nest building wears out the patience of the house owner, who objects to the unsightly domicile of straw under the eves of his home, but also because he drives away other native birds whose presence is more desirable and more advantageous than that of the English visitor. We will say here that those seeking to encourage the wrens to build in bird houses on their grounds should make the entrance exactly the size of a silver quarter. This will admit the wrens, but keep out the undesirable tenant.

While it is apparently impossible to exterminate this bird, which in many ways is a pest, many of us desire to know some merciful way of lessening its numbers. Poisoned wheat, using arsenic in place of strychnine, in order that the birds may not die by the food and thus frighten away others, is used by some. This is open to the objection of danger to poultry, and cats also may eat birds so poisoned. A better way, practiced on some farms, is to feed wheat for a number of days, in the barnyard, say, placing it in a straight line, and one fine morning when the birds are feeding, rake the line with a shot gun. This may sound very cruel to some of our humanitarians, and the Entomologist may be censured for giving such advice, but death is not cruelty, and as this office is intended to relieve farmers of the presence of troublesome pests, he makes the suggestion without hesitation. We know of at least two instances of the successful use of the following: Wheat was soaked twenty-four hours in whisky, and while still moist was placed where the sparrows could get at it, presumably mixed with a small amount of other wheat not treated, and placed where fowls could not well reach it. The result of this was intoxication, maudlin, I am told, in which condition the birds could be readily picked up and disposed of. One case has been called to my attention where this failed, but it was on the farm of a prohibitionist where doubtless the sparrows instinctively refused to touch the grain soaked in spirit. There is some ground to believe, too, that the wheat in this case was not treated with whisky, as the young man told me that he thought it was whisky "but was not sure."

A 22 caliber rifle is sometimes handy, and its skillful use will keep them from forming the habit of roosting on cornices, etc. The tearing down of their nests repeatedly will, after a time, discourage the would-be housekeepers, though they persevere through several buildings before they finally cease.

We have seen English sparrows catching grasshoppers, and know of other good work they do, but it is of such slight import compared with the mischief caused by them, that a slight lessening of their number will do no harm.

GOPHERS, FIELD MICE, MOLES, WOODCHUCKS, RABBITS, ETC.

Everyone has heard the old story about the naturalist who was traveling with some pets, and the railway people had only made provision in their rules for charging for dogs. The ticket seller was therefore in doubt as to whether charges should be made for monkeys, cats and a large tortoise, which accompanied the naturalist. His judgment at last was given forth that the cats and monkeys would have to be paid for because under his instructions, he said, "Cats is dogs, monkeys is dogs, but that 'ere turtle is an insect, so we let them go free." The story does not state whether he would classify gophers and rabbits as insects also. Possibly not. Nevertheless there is no one in the state, outside of this department, so situated as to be able to publish an economic treatise on gophers, field mice, rabbits, etc., all of which are pests to the agriculturist, and as publications from this office are designed for the benefit of Minnesota farmers, the Entomologist does not hesitate to present here his own experience and that of others in combating gophers, rabbits, field mice and allied forms which are hostile to the interests of agriculture.

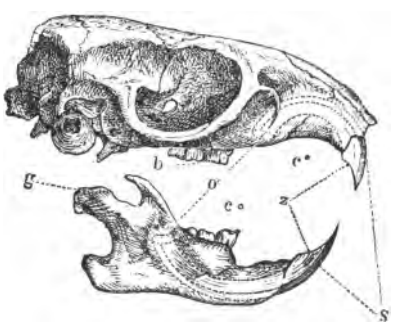


Fig. 137.—Skull of Rat, showing the dentition peculiar to rodents: *S*, hard enamel; *z*, softer dentine; *o*, roots of incisors; *b*, molars; *c c*, centers of semicircles formed by incisors. After Landois.

In the first place, a word as to the classification of these animals as having an important bearing upon their food habits: They all suckle their young and are more or less covered with hair, hence belong to that class of vertebrates known as *Mammalia*. Further, with the exception of the mole, they are all gnawers, and have teeth adapted to that constant habit, the incisors or front teeth above and below being chisel-shaped and remarkably well developed, and the canine teeth being absent. These, therefore, belong to the order *Rodentia* or Gnawers, which order includes all the squirrels, chipmunks, gophers, pouched gophers, rats, mice, rabbits, hares, woodchucks, beavers, muskrats and por-

cupines. The nature of their teeth and the general appearance of their skulls can be appreciated by a glance at the accompanying illustration, Fig. 137. The mole, on the other hand, *does not have the incisor teeth developed for gnawing*, and does have canine teeth in upper and lower jaws. Its eyes are very small, sometimes quite concealed, but with a little care one can find them, hence the popular idea that moles have no eyes is erroneous. They are insect eaters, feeding upon grubs, insects and earth worms, and probably do not often take vegetable matter as food. They belong to the order *Insectivora*, which order includes not only the moles, but also the little mouse-like shrews, in which, unlike the moles, we find no canine teeth. Our illustration, Fig. 138, shows the skeleton of a mole, the sharp pointed teeth, adapted to tearing insects and worms, and *not at all suited for gnawing*, as are the teeth of the gopher. One will at once note in the picture the enormous ridges in the bones of the fore limbs, to which in life powerful muscles for digging are attached, particularly suited to an animal which passes practically its entire life beneath the surface of the ground.

Fig. 138.—Skeleton of Mole. From Brehm.

Turning once more to the order Rodentia, we find it divided into families, and in order to properly place the Minnesota pests which occur in this order, we will arrange the families under the order in such way as to show just where our gophers and squirrels belong and why.

Family *Sciuridæ:* The Squirrels, including all the squirrels, ground squirrels, or chipmunks, the woodchuck or ground-hog, the *thirteen-lined gopher*, the *gray gopher*. All of these have five molar teeth above on each side and four below on each side.

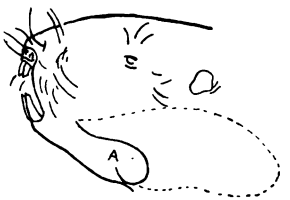


Fig. 139.—Outline of head of Pocket Gopher showing extent and openings of cheek pouch of left side. Original.

Family *Geomyidæ:* Pouched Gophers. This family includes all of our Pocket Gophers. They possess well defined cheek pouches opening *outside* of their mouths on the side of the face, a peculiarity not possessed by the preceding family; furthermore, they have four molar teeth above and below on both sides. Their skulls are heavy and somewhat depressed, their fore feet and claws are large, adapted for digging, and the body is thick and clumsy, quite unlike that of the so-called gophers, found in the preceding family, and so common in Minnesota.

We have in this state two pocket gophers, both of which are injurious. The one, *Geomys bursarius*, is common almost everywhere, especially in our prairie counties. It is reddish brown. The second is *Thomomys talpoides*, a northwestern form, which penetrates the northwestern part of the state. This species is lead color, with breast, feet and tail more or less whitish.

Fig. 140.—Pocket Gopher, *Geomys bursarius*, Shaw. After Merriam.

The injury caused by pocket gophers in a farming community is enormous; not only do they consume large quantities of alfalfa, clover and wheat in the neighborhood of their burrows, eat root

crops such as potatoes, carrots, etc., and kill young fruit trees and vines by gnawing the roots of the same, but their numerous mounds in a meadow destroy, by covering, large patches of grass or clover, and are especially annoying to the farmer in dulling and injuring the knives of the mower.

Fig. 141.—Pocket Gopher, *Thomomys talpoides,* Rich. After Merriam.

Professor Bailey suggests one good thing, probably the only one, accomplished by the pocket gopher. He estimates from observations in Minnesota, that about 500 square feet of soil is covered with subsoil in a season of seven months, and says that by this unique plowing and draining they may do much good, covering a burnt over prairie with a soil which will encourage the growth of vegetation. He has referred, however, to a time when the prairies of this state were frequently fire-swept and not thickly settled as they are now, and, further, it must be remembered that the subsoil brought to the surface may be of very poor quality.

Referring once more to the pockets which characterize this family, an erroneous opinion prevails that these animals use the same for carrying earth from their burrows. Many observations on our own part, indorsed by those of others, lead us to state that this is not the case, but that they carry food in these pockets to be stored in their burrows when not wanted for immediate use.

The family *Muridæ* includes all the rats, muskrats and mice, exclusive of the so-called jumping mice. Here occur the Field Mice, which are so injurious to the would-be fruit raiser and nurseryman, by gnawing the bark from the trunks of young fruit trees in the winter time when the snow conceals their depredations.

Fig. 142.—Field Mice (*Arvicola*). From Brehm.

The family *Leporidæ* includes the hares and so-called rabbits, differing from each other so little structurally that they all, whether "rabbits" or hares, belong to the single genus *Lepus*. In a general way it may be said that the rabbit burrows and the hare does not; that the young of rabbits are born naked and blind, while the young of the hare is born with fur and with eyes open. The meat of the rabbit is lighter colored than that of the hare. In Minnesota we have the Prairie Hare, or white-tailed hare, *Lepus campestris*, which is commonly called "Jack rabbit," found mostly in open prairie country, but rapidly becoming unpleasantly common in farming districts, even though more or less timbered. The Jack rabbit, while slate colored in summer, in winter, as is well known, changes to an almost pure white, the ears only retaining their black tips. This is a fine protection for Jack when there is snow on the ground, but in a snowless winter, their white color against the dull brown of the earth or grass works their ruin. Injury to windbreaks and to gardens from this species is becoming more common every year.

In the timber we get the Northern or varying hare, *Lepus americanus*, sometimes called "Timber Rabbit," which is not especially injurious, since it finds plenty of food close at hand, though fruit trees near the woods sometimes suffer. The bark of the cottonwood appears to be especially palatable to this hare. Brownish in summer time, it turns white in winter, though the hairs are lead colored at base, and a band of brown is maintained down the middle of the back.

Fig. 143.—"Cotton-tail," *L. sylvaticus*, Bachman. A. G. Ruggles.

Finally we get our little Cotton-tail or Gray Hare, *Lepus nutalli sylvestris*, which is common everywhere in the localities favored with a little brush or timber. It is the most destructive of all the hares, in winter time not hesitating to girdle fruit trees, oftentimes gnawing off the tops of nursery trees which project above the drifted snow. Deep snows or drifted snows make the so-called "rabbit-proof" fence useless. In the summer time it occasionally troubles gardens. This species does not turn white in winter.

The family of hares, *Leporidæ*, differs particularly from the other families of the order *Rodentia* by the possession of two small extra

incisor teeth in the upper jaw just behind the large pair; our illustration shows this peculiarity.

Fig. 143½.—Skull of Hare Showing Extra Incisors.

Turning once more to the squirrel family, *Sciuridæ*, we find therein two or three forms which gave us the name of "Gopher State," but which are squirrel-like in their structure. These all belong to one genus, *Spermophilus*, which means seed loving, and, sure enough, we find that they are fond of almost all kinds of seeds—wheat, oats, rye, barley, corn, pigeon grass, millet, sunflower, pig weed, ragweed, black locust, solanum, strawberries, and a host of others. They also eat green leaves, roots of trees and plants, and grasshoppers, crickets, beetles, ants, cutworms, lizards, mice and other forms of animal matter. The members of this genus have pouches but, unlike those of pouched gophers, they are inside the cheeks and not distinct from the cavity of the mouth. Their bodies are slender. They eat like other squirrels, sitting erect and bringing their food to their mouths with their front feet.

Fig. 144.—Thirteen Lined Spermophilus, *Spermophilus tridecim-lineatus*, Mitch. A. G. Ruggles.

First of all, and most abundant of the "Spermophiles" here, is the Striped Spermophile, or striped gopher, sometimes called the Thirteen-lined Gopher, or "Stars and Stripes." See Fig. 144. This animal is common almost everywhere in Minnesota, and is a familiar figure to almost everyone not living in the city. It is reddish brown in color, yellowish below. Counting the rows of yellowish "stars" and stripes, we find thirteen lines in all, which fact gives it its scientific name. Minnesota specimens show the lower stripes on sides indistinct or broken.

We have also the so-called gray gopher, or ground squirrel, or scrub-gopher (see illustration), found on prairies in this state and elsewhere in localities not too much timbered or covered with brush.

Fig. 145.—Gray Gopher, *Spermophilus franklinii*, Fab. After Merriam.

Finally in the prairie country of North Dakota is a serious pest which has pushed east into the Red River Valley but not in sufficient numbers to be destructive. This species is known as the "Flicker-tail Gopher," resembling closely the previous form, albeit it has a short tail and is grayish, while *S. franklinii* is brownish with faint lines of black.

Fig. 146.—*Spermophilus richardsonii*, Fab. After Merriam.

Excluding the moles, the following list of depredations have been laid at the door of the principal pests listed above, by various correspondents:

Jack Rabbits: "Occasionally cut down small patches of grain; gnaw bark from apple trees, causing same to die; cut off tops of young trees; eat a few small melons; eat corn when up three or four inches high."

Cotton-tail Rabbits: "Injure carnation plants in field; plants gnawed die during early months of winter. Eat off small apple trees; bark old ones; one-tenth of nursery stock injured in '98 and '99; five per cent of apple trees killed. Do not eat plum or cherry trees. Eat bark off of evergreen and fruit trees. Cut off yearling apple trees; injure evergreens and girdle plum trees; work in winter, spring and early summer. Ruined hundreds of trees of all ages last winter. No injury except in severe winters, when young apple trees may be gnawed. Ate bark off of apple trees in 1902-3. Girdle young apple trees not protected by wood veneer; when snow goes over this protection they attack lower branches. Destructive to apple trees; will eat off limbs two feet from ground; strip bark from large trees; prefer wild crabs. Eat cabbage plants in summer; fruit trees in winter."

Field Mice: "Lost thousands of evergreens last winter by girdling; have lost apple and other trees. Shell grain out of shock when left standing long, also gnaw bark on apple trees when mulching is left too close. Girdle apple and plum trees, also box elder and ash, shrubs and gooseberry bushes in nursery. Girdled a few dozen nursery trees last year. Eat grain in shocks. Gnaw trees more than rabbits when snow is deep. Considerable damage to nursery stock during winter by working under deep snow drifts; girdle apple or even forest trees which have been mulched with straw. Damage corn and grain shocks when left standing long. Young trees girdled. Damage grain in granary. Damage fruit trees and shrubbery of all kinds. Cut twine on grain in shock. Girdle apple trees occasionally. Damage arbor vitæ where rows are close. Destroy large quantities of corn in field. Very bad on apple and evergreen trees. Eat grain and bands on bundles, also girdle trees."

Thirteen-lined Gopher (Striped Gopher): "Dig up corn and eat other grain. Damage corn in spring when first planted. Dig up newly planted corn, doing considerable damage. Eat seed planted in garden. Damage corn. Injure corn fields by digging down and eating corn just planted, or when a few inches tall, damage five per cent. Dig up corn hills. Dig seed out of ground and eat heads of wheat in shock. Destroy corn just as it is coming out of the ground. Some damage to seed corn. Some damage to grain shocks. Eat newly seeded grain. Much damage in corn fields by digging up corn. Bother a great deal by digging up corn just as it shoots above ground. Much damage done by seed eaten in ground. Considerable damage to corn just planted, also corn in shock."

Pocket Gophers: "Make large mounds in clover fields. Eat roots of young orchard trees and elms. Cut up grain in shock and carry earth up into shocks. Gnaw roots of trees. Cut up hay meadows badly. Gnaw roots off trees and shrubbery. Injurious to fruit trees, five per cent damage. Destroyed nearly half of potato crop last year. Very injurious to roots of orchard trees. A nuisance in clover and potato fields. Go under grain shocks near sloughs, burrow into shock and eat grain, cutting the bands around bundles; about two per cent damage. Damage apple trees

and clover meadows. About two per cent of all crops destroyed. Throw up hills in clover meadows, which are injurious to machinery; often eat off all roots of large apple trees and destroy trees. Destroy carrots and potatoes. Considerable damage in hay land. Damage to apple and evergreen trees. Damage grain and meadows and trees by throwing up mounds of dirt and gnawing roots of trees. Damage grain shocks by carrying dirt into them and eating heads of grain. Considerable damage to shocks of grain. Troublesome in gardens and potato patches. Destroy young trees."

Ground Squirrel or Gray Gopher: "Quite troublesome. Scarce; no damage. Scarce. Not numerous; eat grain. Damage very slight. Eat corn. Very few; no damage. Not numerous. Some damage in corn fields. Scarce; no noticeable damage. Seldom seen. Not injurious. No damage. Sometimes work in grain shocks, cutting the bands. More injurious than striped gopher. Very few of them; dig up and eat seeds just planted."

The scarcity of these animals in most of this state prevents its being classified as such a pest as it is west of Minnesota.

A few farmers who write me labor under a misapprehension as regards the mole. While I have seen this animal in captivity eat peas, and while it may occasionally eat bulbs, *its teeth are adapted to an insectivorous diet, and are not constructed for gnawing as are the teeth of mice and gophers.* Its reprehensible habit of making mounds and ridges in flower beds and lawns will be referred to later. Bearing these facts in mind, it will be seen that some of our correspondents, who write as follows, must be mistaken: "Eat bark of apple, plum, cherry and other trees. Also damage hay stacks by chewing up hay in little pieces." This party is undoubtedly ascribing the work of mice to moles. Another says "Injurious to fruit trees." Another hits the nail on the head in saying "Do no damage, may be beneficial by destroying grub worms.

REMEDIES.

Jack Rabbits: These are kept in check somewhat by gunners and other natural enemies. Poisoning apple or pieces of melon with strychnine, powdering the same and introducing it into slits in the fruit has been tried with some success. One must bear in

mind that strychnine is a deadly poison, and that any stock eating baits poisoned in this way would most certainly die. Corn poisoned in a solution of strychnine—see under Gophers—will kill those which are eating the corn. If fruit trees are injured, in addition to the poisoned bait, they may be wrapped with woven wire, or paper or poultry netting; the latter should be wound around the tree several times. Two correspondents, taking a humane view, say, if they or the cotton-tail are fed with corn, oats or wheat screenings in orchard they are not likely to eat bark. This may be so, but if our apple trees were exposed we would not dare to trust them.

Fig. 147.—A Young "Jack," from Life.

Cotton-tail Rabbits: Sweet apples, poisoned, as described under Jack Rabbits. We would suggest putting out of their reach, while poisoning, all other apples except the poisoned ones, which should be fresh. Watermelon rind or carrots may be used in the same way, though they are particularly fond of sweet apples. One correspondent suggests putting out pieces of apple on little sticks when the snow is deep, so that the bait is raised conspicuously above the surface. He choses moonlight nights for this. Building paper, newspapers, burlap, straw, corn stalks or wire screen placed around trunks of trees are often effective. Some boil strychnine until dissolved and then soak corn in same. A handy gun, if supplemented by a good dog so much the better, is useful at times. The inadequateness of the so-called rabbit proof fence when the snow is deep and drifted is well shown in our illustration (Fig.

160), which represents the case of a nurseryman who, in spite of such a fence, lost a large number of trees through the agency of rabbits.

Mr. Yahnke, the veteran nurseryman at Winona, tells me that for two years he has kept rabbits (and mice) from gnawing his nursery trees by the use of a whitewash made about the consistency of cream, to which has been added enough blue vitriol solution to give the mixture a "robin's egg blue" color. Mr. Yahnke goes between the rows, and with a brush rapidly covers the trunks on the sides next to him with the mixture. The opposite side is coated in the same way. Axle grease smeared on the trunks of young trees is claimed to be effective by some. It would also be unfair to our small boys not to mention the figure four box trap.

Rabbits are much affected with parasites; almost invariably tape worms can be seen in their alimentary canal, and frequently in summer a bot is found hanging on their necks, which later develops into a two-winged fly. There may be several species of bot flies which affect rabbits in this way.

From the December issue of the Minnesota Horticulturist we take the following remedy for rabbits and mice. It looks feasible: "An experienced orchardist recommends the following sure method of getting rid of these orchard pests: 'Make a poisonous solution of one part sulphate of strychnine, one-third of one part of borax, one part of white syrup, ten parts water. This is put into a roomy bottle and well shaken. Now cut fresh twigs from apple trees (water sprouts are excellent); have a small brush, and brush lightly over the twigs, especially the terminal buds. The great value of this over poisoned grain is that it will kill rabbits and mice and will not injure the birds or chickens, while the poisoned grain will kill all. Scatter the poisoned twigs in runways, and places infested with mice or rabbits, and the results will be satisfactory.'"

Field Mice: Perhaps there is no more annoying four-footed pest to the nurserymen than these animals. Heavily mulched nursery rows, or nurseries where oats are planted as a winter protection, are, we believe, more liable to injury than others when snow lies on the ground, or when there is anything which attracts the mice to the trunk, either in the nature of food, or in the nature of a shelter, such as mulch or weeds, or partaking of both these

qualities. The snow melting in the spring discloses their work to the nurserymen, trees oftentimes being completely girdled. Even a girdled tree will live the first season, the sap finding its way to the top through ducts in the wood, but later it is sure to die unless prompt measures are taken to save it. The only way to do this, and it is well worth the time when the tree is a valuable one, is bridge-grafting. Fig. 159 shows what this means, and illustrates the process so clearly that there is hardly need of words. Girdled trees, too small to bridge-graft, may be grafted in the ordinary way below the injury. In bridge-grafting make three grafts rather than two. If large trees are only partially girdled, bridge across the injured place. The tree's own branches may be used for bridge-grafting. In course of time the injury is obliterated by the growth of the bridge grafts. Pressing down the snow and what is below it around the tree with the feet is a help in that it makes it harder for the animals to get at the trunk; there is a solid barrier, as it were, protecting it.

Other remedial or preventive measures are as follows: Keep ground clean of grass and weeds, so there is no place to harbor mice; dig straw away from trees for a short distance; protect trees with wire mosquito netting wrapped once around trunk, about fourteen inches high, or with wood veneer, or with building paper; bank with dirt before freezing weather six or eight inches above surface. Mice may be poisoned with strychnine, using corn meal mush or wheat or corn, scattered about bases of trees. Poisoned wheat already prepared can be purchased in some places. Cats are instrumental in keeping down field mice; some dogs delight in hunting them, and hawks and owls reduce their numbers. Strychnine, as mentioned eleswhere, must be used with caution, that live stock or poultry may not suffer. *It should, of course, be kept out of the reach of children.* Cats eating mice or gophers which have died from strychnine poisoning would probably suffer the same fate as the animals they fed upon. Skunks are said to do us a good turn by eating field mice.

Thirteen-lined Gopher or Striped Gopher: Corn soaked or dusted with strychnine, placing a spoonful in each hole, is a good remedy. Wheat, if used, or corn, should be soaked for twenty-four hours in a solution containing strychnine, and where the

strychnine is dusted on the grain, the latter should be moistened so that the grains of poison will adhere to the kernels. The solubility of strychnine is slight. A teaspoonful of the crystals boiled in 2 quarts of water would make a solution sufficiently poisonous and is probably all that amount of water will take up. This solution may well be sweetened with sugar or syrup.

Steel traps are useful against these animals, and the writer remembers that, as a boy in Minnesota, he used to place a slip-noose occasionally over a hole, and when Mr, Gopher showed his head, as he was quite sure to do very shortly, he was easily snared by the boy at the other end of the string. A shot gun or a 22 rifle would be useful in this connection.

Gray Gophers or Ground Squirrels: The same poisoned baits are used successfully against these as against the thirteen-lined gopher just discussed, and field mice, but they are not generally numerous enough in this state to call for special measures beyond those offered by shooting or trapping. In a far western state, where they are much more numerous than here, the writer used to place poisoned wheat in long covered boxes (about two feet long and ten inches square), the ends being closed except for a space of about three inches wide at the bottom; this allowed gophers to run through but kept out poultry and anything else which might eat the poisoned wheat not intended for them. These boxes were placed on the ground in fence corners in infested fields.

Pocket Gophers: In order to understand fully the application of various remedies and traps against these pests, it is well to have

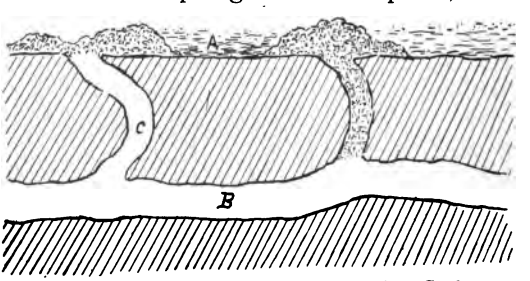


Fig. 148.—Diagram of Burrow of Pocket Gopher.

an idea of their burrows. Fig. 148 illustrates somewhat crudely the main burrow, about two feet below the surface of the ground, and

two of the branch burrows leading from it to the surface, and affording means of removing the earth dug from the main burrow. The mounds of earth one sees mark the places where these branch burrows were open and later closed. The last one made that marks the end of the main burrow, is frequently found open, as that is nearer the location of the animal's work, as he tunnels in some desired direction, possibly toward a patch of potatoes, or along a row of potatoes, or toward some promising clover field. By pouring about ½ pint of bisulphide of carbon on a piece of old burlap or oakum, thrusting it quickly down this open branch burrow, preferably when the soil is moist, and then stopping the aperture with earth, the writer has killed many. Nevertheless the main burrow is sometimes so extensive in its length that treatment with this poisonous gas is not always successful, and recourse must be had to poison. I have been extremely successful with strychnine poisoning, proceeding in this way: The crystals of strychnine were powdered in the bottle in which they were purchased, by means of a large headed nail. Having previously provided myself with an old spoon tied to a long stick, I made slits in a piece of potato with a pen knife, and with the same blade introduced a little powdered strychnine, the poisoned piece of potato was then placed in the spoon, which was thrust away down the hole, turned over and withdrawn, thus leaving the bait in the burrow without having had to put my hand in, the scent of which might alarm the gopher. Another and perhaps simpler way, when the ground allows, is to take an old spade handle or shovel handle of the short kind, sharpen it and thrust it through the soil in the course of the main burrow, and when quite sure that has been reached, dropping in the poisoned potato, and gently pushing it with the spade handle until you are sure it is in the main burrow. Or, if all the branch burrows are filled, one can carefully remove the earth from one of them and introduce the spoon containing the poisoned potato therein. Some claim that they have had better success with parsnips than with potatoes when using poisoned bait.

I have also had success with an ordinary steel trap, digging down to the main burrow with a spade, excavating a place for the trap on the floor of the burrow, covering the set trap lightly with soil, and then placing a piece of board on the surface of the

ground, covering the hole I had made, and heaping earth on the board. I have also used with equal success against pocket gophers and against moles in lawns a cheap trap gun shown in Fig. 149. I believe this is one of the few so-called gopher traps

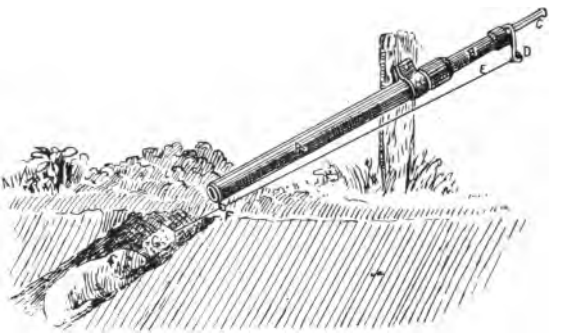


Fig. 149.—Gopher Gun.

worthy of notice. It is made of a piece of gas pipe, and shoots a central fire Winchester shell of small size. Only a small load is required to kill either a gopher or a mole. This gun is fastened to a peg which is driven down in front of the gopher's hole; a piece of potato, or cork or corn cob is put on the end of the wire (see illustration) which extends in front of the nozzle and down the hole, being connected with the trigger at the other end. The gopher, in seeking to cover up the hole and thus exclude the light,

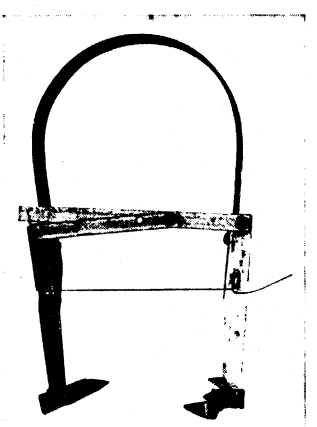


Fig. 150.—A New Gopher Trap, Set.

Fig. 151.—The Same Trap, Sprung.

pushes earth before him, it presses on the cork or potato, fires the gun and never fails to kill the animal in the burrow. A trap said to be excellent, of comparatively recent invention, is shown in Figs. 150 and 151. This is placed in the gopher's burrow, and is kept set by a string, as shown in Fig. 150. The animal seeing this string, and realizing that it is foreign to his dwelling, proceeds to gnaw it. The result of his biting the string is shown in Fig. 152. The trap sells for 35 cents, three for $1.00, and is manufactured in Chicago.

Fig. 152.—Pocket Gopher caught in Trap.

The prominent front or incisor teeth or rodents, upon which so much depends in the way of subsistence, are peculiar in that while the front of each tooth is hard enamel, back of this is comparatively soft dentine, the enamel in front being much thicker than anywhere else on the tooth, and the chisel-like sharpness of these teeth is brought about and maintained in each case by working against the opposing tooth in the opposite jaw. As we can readily see, the working of the enamel edge in the lower teeth against the inner or dentine surface of the upper teeth, and vice versa, would result in a sharp enamel edge in both upper and lower teeth. If, as sometimes happens, through disease or by accident one incisor is lost, or both, the opposing tooth or teeth in the upper or lower jaw, as the case may be, keeps growing, not being worn away at the free end, as would be the case normally, and completes an arc

of a circle outside of the jaw, resulting in a deformity, if it is the upper teeth, something like the illustration shown in Fig. 153.

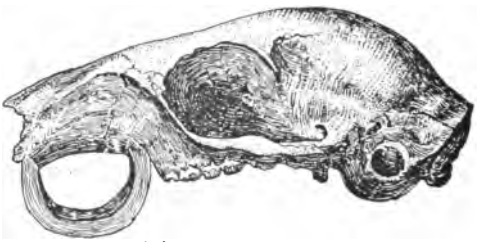


Fig. 153.—Skull of Squirrel showing abnormal growth of upper incisor teeth. Standard Natural History.

Woodchucks: The accompanying excellent illustration shows an animal familiar to us all, and generally not so abundant or injurious but that the farmer's boy and a steel trap are quite equal to the occasion. Bisulphide of carbon is also used successfully, and at least one party known to the writer has had recourse to the somewhat dangerous use of blasting powder.

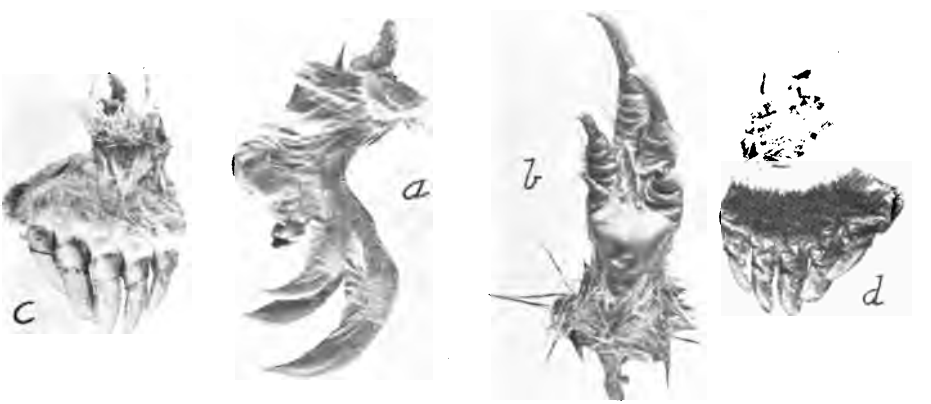
Fig. 154.—Woodchuck. *Arctomys monax.*

The gas generated by bisulphide of carbon is inflammable; keep all lights, pipes, cigars or matches away from it.

Moles: I regard moles as more beneficial than injurious, and dislike to offer any means of killing them. At the same time they

Fig. 155.—A Mole. From Müller.

are sometimes so aggravating in mining lawns that some remedy is called for. In some parts of the country moles have certain times of the day when they work. Knowing this and seeing their mounds move at such times, we may, as has the writer, stand with a many-tined fork over a mound, and when the movement is repeated plunge the fork as accurately as possible into the middle



Figs. 156 and 157.—*a* and *b*, Feet of Gopher; *c* and *d*, Feet of Mole, from above and below. Lugger.

of the moving area. The chances are that the mole will be impaled on the fork. A light charge of shot fired into the mound at such a time at close range, using but very little powder, would undoubtedly accomplish the same result, and would perhaps be more sure.

Fig. 158.—Ear of Corn gnawed by some rodent. Supposed by a Correspondent to be the work of Insects.

I have killed many moles in lawns by the use of the gopher gun shown in Fig. 149, opening the surface burrow, leaving it open, and having the gun point into it. Moles have burrows much like gophers, that is, a main burrow and branch burrows coming

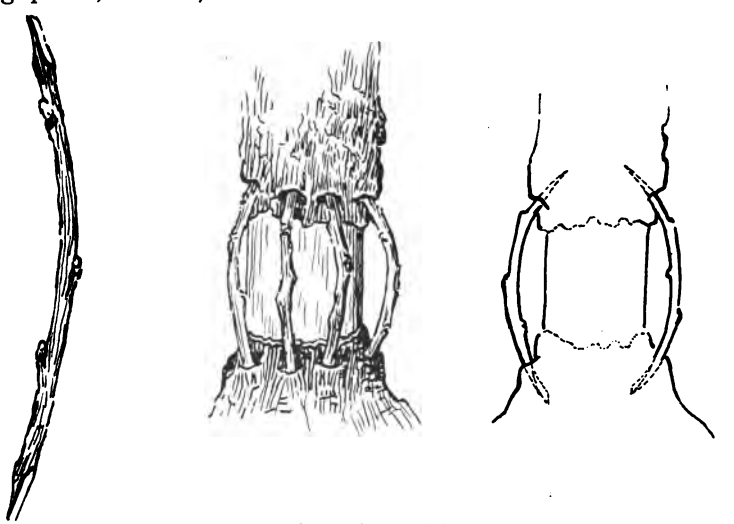


Fig. 159.—Bridge-grafting. After Thomas.

therefrom. The surface burrow, which raises the sod in ridges, is quite distinct from the main burrow, which lies deeper. The surface burrow is made, I believe, by the mole in pursuit of grubs or worms among the grass roots or just below.

I have no faith in attempts to poison moles, and believe poisoned wheat or corn or meal is absolutely of no avail in this connection. Moles appear to be almost entirely carnivorous or meat eaters, and the meat must be living apparently. Wheat, corn or meal is not attractive to them. The ordinary steel trap is sometimes used with success. One writer claims, upon what ground I do not know, that moles are very fond of sugar, and that

Fig. 160.—A "Rabbit-proof" Fence which is not always true to name.

if it is slightly poisoned with powdered strychnine and placed in their burrows, beneficial results follow. The Entomologist wishes again to caution those who use strychnine. It is a deadly *poison* and should be handled with the greatest care.

THE COMMON TOAD A FRIEND TO GARDENERS.

Most of the old superstitions regarding the toad, such as the possession of a jewel in its head, and that warts are produced on one's hands from handling, etc., have been pretty much done away with. We hear astonishing stories regarding the finding of live toads encased in solid rock, in wood, etc., evidence going to prove that they have been thus buried for many years. These stories are not authenticated, however, and may be looked upon as myths. The ancients believed, too, that toads had medicinal value; that broth made of toad's entrails was poisonous, that any part of the toad if eaten would cause death, that killing toads on the farm would make the cows give bloody milk, etc. These and similar superstitions have given away before modern education. Nevertheless, that toads are long lived, and may endure what would seem to be unfavorable conditions for a long time, is well known. We hear of a toad in Europe said to have reached the age of thirty-six years before it was killed by accident. We are told by Mr. Mosher, a most careful observer, that he has "positive knowledge of a toad which had occupied a door yard for at least eight years." Other testimony regarding the longevity, not so satisfactory, claims twelve years for one and twenty-three years for another. These statements may be correct, but we lack absolute proof. Of particular interest, and having a bearing upon the reports that toads have been found encased in rocks, etc., is the fact that Mr. Herrisant in 1877 placed three toads in sealed boxes of plaster, and found two of them alive when the boxes were opened eighteen months after. Later experiments along the same line, however, indicate that they are not capable of standing such imprisonment without food for an unlimited time.

Very few realize the immense good done by the common toad in consuming insects which are, for the most part, injurious to the flower and vegetable garden. He is a true insect hunter and therefore deserves a place in the Entomologist's Report.

A few words as to the life history of the toad may not be out of place. In the spring of the year both sexes repair to pools and

THE COMMON TOAD.

A Practical "Bug Catcher" and therefore a Useful Friend. Encourage His Presence in Your Gardens.

Courtesy of R. A. Cooley.

ponds for breeding, and the air is filled at that time with that shrill purring which is so characteristic of the early spring, when the poplars and cottonwood are in bloom and the first moccasin flowers are found in the woods.

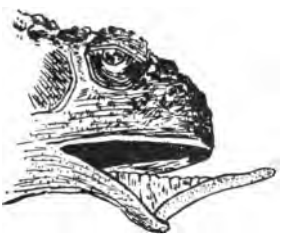


Fig. 160½.—Head of Toad, showing the peculiar attachment of the tongue. After Kirkland.

The eggs, to the number of 1,000 or more, unlike those of the frog, are laid in strings of gelatinous matter wound about aquatic or submerged grass. These eggs hatch after a while into tadpoles or polliwogs, much resembling the tadpoles of the frogs, which breathe for a part of their lives by means of gills, and are familiar to every farmer's boy and any one at all observant in the fields and woods. These so-called polliwogs after a while lose their tails, acquiring first hind legs and then fore legs, while their tails are disappearing. Losing their gills, they finally breathe entirely by means of lungs. Then they emerge from the water in large numbers. They avoid the sun, and both old and young are

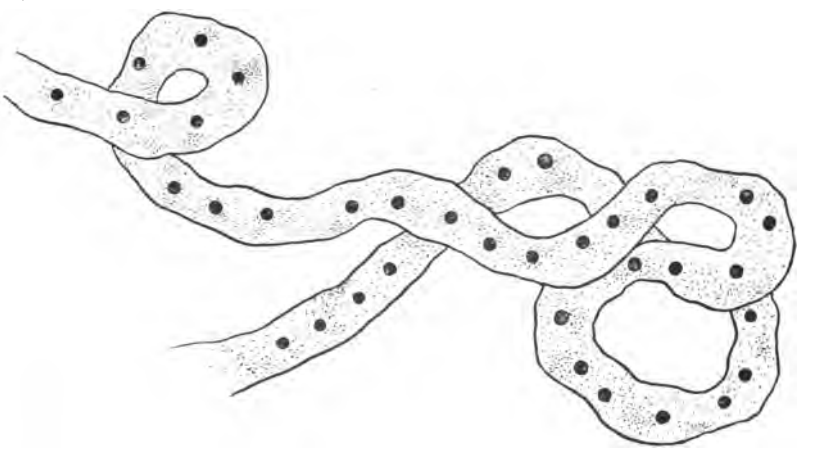


Fig. 161.—Toads' Eggs.

seen at night-fall, or sometimes in large numbers after a rain, at which latter time their extreme abundance gives rise to the popular belief that "it is raining toads."

Those of these young creatures that escape their enemies (and their foes are extremely numerous) begin before very long their

useful work of feeding almost entirely upon insects and allied forms, and the number of insects which they consume, as adults, is almost incredible. Some excellent work done by A. H. Kirkland, of the United States Department of Agriculture, and published in Farmer's Bulletin No. 196 (which is practically a reprint of his work published as Bulletin No. 46 of the Hatch Experiment Station), brings to light the startling fact that in twenty-four hours the insect food consumed equals in quantity four times the capacity of the toad's stomach. In other words, the stomach is practically filled and emptied four times in each twenty-four hours. Mr. Kirkland states further that 149 stomachs examined by the Department during the months of April, May, June, July, August and September showed 19 per cent of ants, 16 per cent of cut worms, 10 per cent of thousand-legged worms, 9 per cent of tent caterpillars, 8 per cent of ground beetles and other close allies, 6 per cent of May beetles and allies, 5 per cent of wire worm beetles and allies, 5 per cent of destructive weevils, 3 per cent of miscellaneous caterpillars, 3 per cent of grasshoppers and crickets, 2 per cent of spiders, 2 per cent of sow bugs, 1 per cent of potato beetles, 1 per cent of carrion or burying beetles, 1 per cent of miscellaneous beetles, 1 per cent of snails, 1 per cent of angle worms, 1 per cent each of vegetable matter and gravel probably taken in with the insects, and 5 per cent of unidentified animal matter.

In considering the value of the toad as shown by this work, we must remember that ants, while not directly injurious to the agriculturist, are a pest to the housekeeper, sometimes injure lawns, and always encourage by their assiduous devotion and attention destructive plant lice. The toad makes a fine showing in the above percentages on cut worms. The thousand-legged worms eat into fruit when off the tree; the injurious qualities of the tent caterpillar we are well aware of, and we also know that but one or two birds will touch them on account of their disagreeable covering of hairs. Ground beetles are, for the most part, beneficial, but May beetles or June bugs, as they are sometimes called, of which the above toads ate six per cent as compared with the rest of their food, we all know are most destructive upon lawns, strawberry

patches and elsewhere. The wire worm beetles, as we know, are the source of one of our most destructive pests, both in the garden and on the farm. All weevils are exceedingly injurious, and the rest of the list needs no comment, except possibly spiders and sow bugs. Spiders may be beneficial in killing injurious insects, but their webs also catch beneficial insects, forms which live as parasites or prey upon the injurious forms. Sow bugs, which belong to the class Crustacea and are not insects, sometimes do great damage in green houses by eating tender roots and plants, and are always obnoxious things to have in the vicinity of the house. The carrion beetles or burying beetles are useful to man. Snails are a pest of the flower bed. Angle worms, of which the above toads consumed a small amount, are beneficial in draining soil and turning it over, but sometimes are unpleasantly injurious in flower beds and on lawns and about walks.

Our friend, the toad, eats grape and celery caterpillars, tomato worms, the destructive cabbage worm, cucumber beetles and canker worms. Some bee-keepers, alas, say they occasionally eat bees. Upon this point Mr. Russell, President of the Minnesota Bee-keeper's Association, tells me that he has fed a toad by throwing drones at him, the toad never missing a drone, but catching each one most adroitly, and with but the slightest evident effort. On account of this one apparent weakness, and even the best of us have our weaknesses, as well as for other reasons, bee-keepers should keep their hives off the ground. It is well to remember, however, that toads do most of their feeding at night when bees are not active. We have never witnessed any such reprehensible act on the part of the toad.

Mr. Kirkland, in summarizing his work, says, excluding the five per cent of unidentified animal matter, that the food of the above toads represented 11 per cent of beneficial forms, 22 per cent neutral forms, or forms which affect the gardener or the farmer neither one way nor the other, and 62 per cent of very injurious forms. Let us give all credit, then, to the toad for his good work, and let us encourage his presence in our gardens as well as in our greenhouses in every way possible. **Perhaps the worst enemy the**

toad has is the thoughtless boy, who sometimes brags of the number of toads he has killed in the spring, not realizing that he is not only killing a perfectly harmless creature, but that every toad he kills would, if allowed to live, have consumed thousands of insects which prey upon plants of the garden and the farm.

The toad's food must be alive in order to attract him, and it is astonishing with what lightning-like rapidity his tongue is darted out and drawn back with an insect. Awkward as he appears, he is frequently quick enough in this process to catch an insect while on the wing. This tongue, with which he accomplishes this marvelous work, unlike the tongue of most other animals, is attached at the anterior end and free behind, admirably fitted, it will be seen, for its purpose.

We are indebted to Prof. R. A. Cooley of Montana for the use of the photograph which precedes this article.

Fig. 162.—"They Work While You Sleep." (*Bufo vulgaris, B. variabilis* and *B. calamita.*) From Brehm.

REMEDIES FOR SOME COMMON PESTS OF THE VEGETABLE GARDEN.

Some insect pests, like the poor, we have always with us, and to forestall many inquiries which will reach this office in the future, as they have in the past, we include here remedies for these common insects, even though they may have been treated of before. These pests are everywhere more or less abundant, and possibly with one exception, so well known to our farmers that we omit descriptions, confining ourselves simply to remedial measures.

Cut Worms: Late fall plowing, thus bringing up the pupæ where they are subject to extremes of temperature, and the attacks of blackbirds, crows, poultry, etc. Cleaning up and burning all rubbish. Poison bundles of clover with a strong solution of Paris green and strew the same among the plants which are being cut. We have been successful with these poison baits. Plant an excessive number of seeds or plants. Cylinders of tin, fruit cans with ends melted out are good, or cardboard, or even paper placed around young plants, melons, squashes, cucumbers, etc., and extending into the earth two or three inches will protect plants until they get beyond danger. We have trapped them by placing flat on the ground cabbage leaves or any large leaves or boards among plants needing protection, finding the worms underneath these traps in the morning. We have frequently found the guilty worm concealed an inch or two in the soil in the morning, not far from the plant injured in the night. We have poisoned them by making a bran mash, sweetening it with molasses or sugar (it should not be sloppy) and adding Paris green liberally. Place one or two teaspoonfuls of this near the base of each plant likely to be cut. It should not be placed too near tender plants—beans, melons, cucumbers, etc.—since a heavy rain would wash the Paris green against the plants and injure them. Arsenic may be used in place of Paris green, observing the same precautions. Land recently in sod is likely to be infested, and the crop following sod is pretty sure to suffer, if attractive to these pests. Nursery trees affected by climbing cut worms may be sprayed with Paris green, or cotton or tin barriers fastened about trunks, or a ring of one of the various sticky compounds on the market placed around the trunks.

In using any of the above remedies, or, in fact, remedies for any insect, each farmer or gardener must be guided in making his choice by the conditions existing with him. Some of the above, for instance, would not seem practicable to one farmer or gardener, while they would exactly suit the conditions existing with another. It is the policy of the Entomologist to give as many good remedies as possible in each case in order to allow of a choice.

Wire Worms: Frequently abundant in sod land, and troubling crops following sod. Fall plowing as for the cut worm, and repeated several years in succession, is desirable, since they live more than one year in the larval stage. The writer has trapped them in a patch of beans, by sticking pieces of potato on slender sticks eight inches long, and burying the potatoes three inches near the roots of the bean plants, examining the potatoes every few days

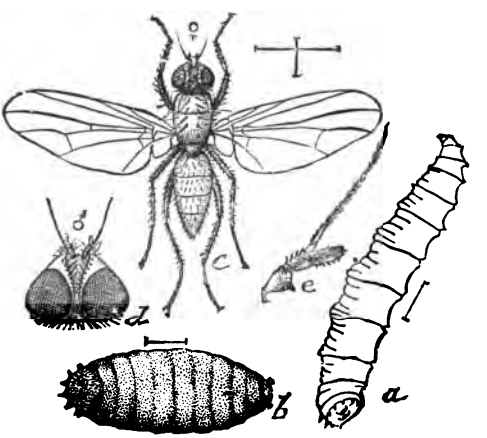


Fig. 163.—Cabbage Maggot, *Phorbia brassicæ*: *a*, Larva; *b*, Pupa; *c*, Adult; *d*, Its head; *e*, Antenna. From Riley.

and killing the wire worms found feeding thereon. This, of course, is not practicable for field crops. Rotation of crops as far as possible is desirable. The adult insects may be attracted to poison baits in the spring. Certain commercial fertilizers are recommended, but are not altogether satisfactory. The worms are the larvæ of Click Beetles, see Fig. 72.

Cabbage Maggot: The larva of a small fly, boring into roots of cabbage, cauliflower and radishes. Other closely allied flies affect onions, beans, etc. One market gardener reports having lost

15,000 cabbage plants and 10,000 cauliflower plants, practically his entire crop, through the agency of the cabbage maggot. He states further that the fly worked right through September, and was as bad on late cabbage as on early. The number of cabbage or cauliflower plants set to an acre is small compared with beans or onions on the same area; hence, remedies may be applied to cabbage or cauliflower which would not be practical for beans or onions. These flies lay their eggs upon the surface of the ground near the stem, and the maggots, hatching a day or two later, work through the ground to the stem. One means taken to prevent attack consists of round discs of the cheaper grades of tarred paper, about 4 to 4½ inches in diameter, with a slit cut from the edge to the center. These are slipped around the stems of the plants, and made to lie flat on the ground. To be effective they must be applied *before the eggs are laid.* The idea is to keep the fly which lays the eggs away from the stalks where they enter the ground, obliging her if she lays at all, to lay her eggs so far from the plants that the maggots cannot reach them. Onion plants infested by maggots, evidenced by the yellowing and wilting of the leaves, should, if weakened beyond all hope of recovery, be pulled and destroyed, that the maggots therein may not develop and spread the mischief. In bad cases weak kerosene emulsion might be employed along the rows, wetting the stalks and adjoining soil. This would, to some extent, if used frequently, repel the fly, and possibly kill some of the larvæ which might not be protected. One party claims to have obtained relief by making an application of about a thimbleful of common salt about the root stalk. We have never tried this, but would remind our readers that while a little salt is good for plants it should be used with caution in connection with flowers or most vegetables. Finely ground tobacco, or soot, or ashes, or air slaked lime, or sand wet with kerosene, a cupful of kerosene to a pail of sand, is sometimes applied around the plants, or along the rows. This must be done before the eggs are laid. When the maggots are working on the stem, kerosene emulsion or carbolic acid emulsion has been used with success. Carbolic acid emulsion is made as follows: Dissolve 1 lb. hard soap in 1 gal. boiling water, add 1 pint crude carbolic acid, and churn through force pump. When wanted for use against cabbage maggots dilute it

with thirty parts of water. Dilute with 35 parts of water when used against radish maggots. About one-half pint of this emulsion should be poured about the base of each cabbage plant. The recipe for kerosene emulsion is given in Report for 1903 (Bulletin 84). Against the radish maggot the writer has successfully used, in a small garden, tobacco water making several applications with a watering pot, beginning when the radishes were quite young. The tobacco solution not only acts as a repellant, but is also an excellent fertilizer. He has also used ashes and slaked lime.

We note that when radishes are raised on a large scale the following compound is recommended (J. B. S.): Nitrate of soda 700 lbs., ground rock 1,000 lbs., muriate of potash 300 lbs. This should be applied at the rate of 500 lbs. to the acre, sown after plants are up, "when the leaves are about an inch long" and should be used during or before a rain. Applied too late, after the insects have got into the roots, it would be a waste of time and money as far as a remedy against the maggots was concerned.

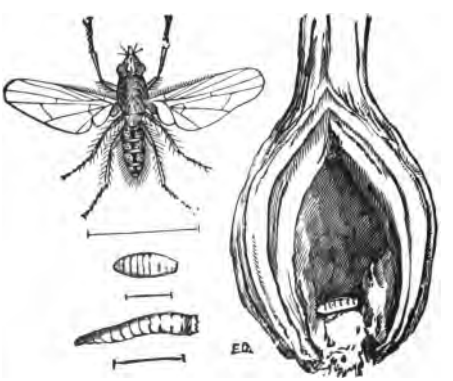


Fig. 163½.—Onion Maggot.

Cabbage Worm: This green worm, the larva of the white cabbage butterfly, not only attacks cabbage, cauliflower, kale, etc., but various kinds of cruciferous plants. We believe in paying children something to hand pick the worms and kill them, and also to make nets of mosquito bar in the early summer and catch every white butterfly they see hovering over the cabbages. A small sum

expended in this way will not only please the young people, but will work astonishing results. Three children in about 2½ hours collected in the writer's small garden 360 green cabbage worms.

Dusting or spraying with Paris green has been successful. Paris green may be mixed with cheap flour, 1 lb. of Paris green to every 25 or 50 lbs, of flour, and dusted in the morning upon the plants when the dew is on. Or the cabbage may be sprayed, using 1 lb. of Paris green to every 160 gals. of water, and adding some soft or hard soap to prevent the liquid "rolling" off the cabbage leaves. In using Paris green in water keep the solution constantly stirred. Hellebore dusted on in the early morning can also be used, if one objects to Paris green. We will say in this connection that there is absolutely no danger of poisoning when Paris green is used on cabbage, since not a trace of the poison will be found in the head itself. Hellebore is poisonous to insects, although harmless to man.

Squash Bug and Cucumber Beetle: See pages 80 and 81 respectively.

Stalk Borer in Tomato Vines: See page 178.

Naked Snails or Slugs on Lettuce: See page 180.

To Get Rid of Potato Blight and Potato "Bugs" at the Same Time: In traveling over the state the latter part of last summer I was struck by the prevalence of blight in potato vines in many sections. Since then many complaints have reached us regarding this trouble. The following treatment with Bordeaux mixture has, in New York State, given excellent results, and a knowledge of the method, it would seem, should be in the hands of every farmer in our state who raises potatoes.

Spray the vines with Bordeaux mixture first when plants are six or seven inches high. Two weeks later give them another spraying, following this with two, three or four later sprayings, even nine and ten sprayings are sometimes given, allowing two weeks to elapse between applications. The necessary strength of Bordeaux mixture for this purpose is made as follows:

Place six lbs. of copper sulphate (bluestone) in a burlap sack, and hang it in sufficient water to dissolve it in any vessel which is

not made of iron. Slake four lbs. of fresh lime gradually. When slaked add 25 gals. of water, and the water containing the dissolved bluestone. Stir thoroughly and add 25 gals. more water, 50 gals. in all. This mixture should be strained through burlap, or, better, a wire strainer, before being used, to remove particles which might clog the sprayer. To kill potato beetles or "bugs" at the same time, add one lb. Paris green to the amount of the mixture necessary to cover one acre. Each plant must be thoroughly covered. To be successful the spray should be used before the blight starts. This process (four sprayings) costs about $4.00 per acre, and each farmer must decide for himself whether the expense is justified.

It may well be said here that when one is treating potato vines for the beetle alone, arsenate of lead is safer and better than Paris green.

Farmers should read in this connection the article on potato diseases, page 66 of Farmers' Institute Annual No. 16. These Annuals are obtained by mailing a request to O. C. Gregg, New York Life Building, St. Paul, Minn., enclosing postage.

Potatoes this year are much troubled by rot, which subject, as well as that of potato blight, naturally belongs to another department, and does not call for detailed discussion here. We are led to say, however, that the old theory that potatoes should be dug early to avoid rot appears to have been disproved in the light of certain recent experiments, in which only 7 per cent rotted when they were allowed to remain in the ground ten days after the tops were all dead, while some which were dug much earlier lost 55 per cent by decay. It is claimed that the common dry rot of the tuber is caused by the same fungus that produces the late blight of the foliage, and potatoes in blighted fields are likely to be infested with rot; if not during the same season in which the blighted tops appar, then the following. It is believed by some that the spores are washed down by rain into the soil. Said spores would remain dormant for a while, until favorable conditions for germination occurred. Much remains to be learned on this question.

ENTOMOLOGICAL SUGGESTIONS FOR THE FLOWER GARDEN.

Without attempting to list remedies against the army of insects which attack the flower garden, simple remedies against some of the more common forms, which the Entomologist has found useful in his own experience, may be helpful.

Plant Lice: These are perhaps the most vexatious of all to those seeking to raise flowers. We find various kinds in the flower garden, on golden glow, sweet peas, roses, spirea, buckthorn, etc., all busily engaged in sucking sap from their various host plants, frequently blasting our hopes of flowers, or good growth of plant or bush unless we take prompt measures against them. We cannot well use the usual radical remedies which are sure death to lice, since they would either destroy the tender growth of the plants, or hide by their offensive odors the delicate fragrance of the flowers.

Occasionally on sweet peas or other delicate plants, a forcible spraying of water from the garden hose, frequently repeated, will wash them off. Fresh pyrethrum dusted on them with a bellows will, of course, kill them, and is an excellent thing if one can buy the fresh material. On shrubbery from which no flowers are to be gathered, whale oil soap, tobacco solution, or weak kerosene emulsion can well be used. More convenient, easily prepared, and adapted to all flowering plants is the following soap solution: A 5c. cake of Ivory soap dissolved in eight gallons of water Possibly other soap could be used as well as Ivory Soap, but the latter is found in almost every household, and has been successfully used

Cut Worms: Frequently cutting dahlias and other tender plants. See page 171 for remedies.

Stalk Borer: This disgusting "worm," found in the growing shoots of dahlia, hollyhock, golden glow, aster, catalpa, etc., is frequently as troublesome in the flower garden as in the vegetable garden, in which latter place it attacks tomatoes, potatoes and other plants, and some shrubs whose stems have a soft center. It is the larva of a brownish moth, and there appears to be more than one brood during the summer in Minnesota; at least, we have obtained pupæ from hollyhocks in August, and had the moths

emerge on September 7th. The young caterpillar, on emerging, is purplish, with eight stripes running along the body. Later it becomes duller colored, and about midway of its length the color is such as to make that part appear diseased. The presence of this borer in a stem is indicated by a drooping and wilting of the growing tip and examination will disclose a round hole on the surface of the stem, below the wilted portion, the opening of its burrow. The affected stem can be cut off just below this hole, and the "worm" in its burrow be killed; or, in rare cases a slitting of the stem on one side, above the hole, with a penknife will bring the culprit to view. If it is not found in the burrow above the hole, one must note whether any part of the burrow is in the stem below the hole; if so, the caterpillar must be sought for there. If these precautions are taken at the very first appearance of the drooping of the plant serious injury may be prevented, and further trouble by these worms turning into moths and laying more eggs, averted. In stems which are straight, offering no irregularity in growth, a flexible wire may be run up in the burrow, or down through the opening, and the caterpillar killed in this way. Most feasible af all, possibly, is the method hit upon by a Minneapolis party whose choice tomato vines were being injured. With a medicine dropper he injected into each hole about one teaspoonful of chloroform, immediately plugging the hole with a bit of cotton, that the fumes might be retained. This worked like a charm, did not appreciably injure the tomato plant, and would doubtless be effective upon flowering plants. We have suggested the use of bisulphide of carbon in place of chloroform on the ground of its being less expensive, and have been informed that it has been found quite as successful as the chloroform.

Cabbage Worm: This vegetable garden pest finds also food to its liking in the flower garden. The writer had a fine growth of nasturtiums last season, which, in late summer, were badly eaten by the larvæ of the white cabbage butterfly. We resorted to hand picking. See in this connection the remedial measures discussed on page 174.

Rose Beetle, Rose Chafer, "Rose Bug": This yellowish beetle, being a leaf eater, can be easily killed by an application of some internal poison, like hellebore. By jarring the bushes in the morn-

ing they can be readily shaken into sheets placed below to receive them. They sometimes appear in large numbers when roses begin to bloom. Frequently grapes, apples, plums, etc., also suffer.

Slugs, Slug Caterpillars: These worms, found in leaves of various bushes and shrubs, are larvæ of four-winged flies. They are not true caterpillars. Two forms are found on the willow; one black with orange spots on the side; another, larger and green. Some feed on leaves of cherry, plum and pear; others on roses. Some have a slimy covering, while others look more like a genuine caterpillar. They are all leaf eaters, and can be easily killed, therefore, by Paris green sprays, or white hellebore, 1 oz. in 1 gal. of water, or dry, or tobacco solution. The slimy form can be destroyed by dusting with air slaked lime, fine ashes or even road dust, and they will all yield to pyrethrum.

Mildew on Roses: This fungus which attacks the leaves of roses, as well as many other similar parasitic plant growths, has been controlled by the Entomogolist by the application of "potassium sulphide" (liver of sulphur) using 1 oz. dissolved in a gal. of warm water, and sprayed on bushes at the *very first appearance of attack*, repeating the treatment occasionally. If one delays application until the fungus has worked into the tissues below the surface, the above fungicide cannot reach it. Hence, the necessity of early and frequent applications. If roses calling for treatment are trained against porch or house, avoid getting the liquid on the paint; white paint particularly is badly discolored by it.

Small Ant Hills in Lawns and Walks: The writer has stopped the depositing of sand by ants on a lawn by the same agent used against the large unsightly mounds made by one species in our pastures and elsewhere, though it is somewhat more laborious and expensive. The process consists in pouring into the opening of each ant hill about ½ teaspoonful of bisulpide of carbon, and then closing the opening with earth. It would hardly pay one to treat occasional, very small and scattering hills in this way, but occasionally one will be annoyed by a cluster of hills, the owners so busily engaged in bringing up sub-soil that an unsightly patch on lawn or walk results. When several so located have been treated, throw a wet burlap sack or something of the kind over them for several hours to still further aid in retaining the gas. When a cluster of

hills, as above indicated, is found in the lawn, and the ground seems more or less honeycombed by their burrows, punch several holes from two to four inches deep at intervals through their villages, using something like a sharp croquet stake, and pour about a teaspoonful of the above liquid in each, then cover with earth and burlap, as suggested.

The minute ants, *Monomorium*, which sometimes get a foothold in the house, annoying careful housekeepers, can only be eradicated by finding the nest or nests, even though it is necessary to remove some carpentering to do so, and killing the queen or queens. Sometimes she can be reached by squirting kerosene, using a machine oil can, into cracks and crevices in the immediate neighborhood of the nest. There are various ways of temporarily alleviating the trouble, but no permanent relief can be expected until the queen, the source of all the eggs, is killed. Bisulphide of carbon, observing the usual precautions as regards the proximity of lights, is sometimes successfully used.

Naked Snails, "Slugs": These must not be confounded with the "rose slug" or "pear and cherry slug" or "willow slug" discussed above, which are insects. The subjects discussed in this paragraph are not insects at all, but belong to the group or phylum of animals known as *Mollusca*—soft bodied creatures, frequently covered with a shell, such as our pond snails, clams, oysters, etc., but sometimes without, like these slugs which crawl about flower beds, frequently eating violets and pansies, and in some sections notoriously troublesome on lettuce in the vegetable garden.

Moist ground is always more likely to be frequented than dry situations, hence, drainage, where practicable, tends to lessen their numbers. I have trapped them by placing cabbage leaves flat on the ground among plants infested, leaving them there over night, and finding Mr. Slug underneath in the morning, he having sought that protection against the heat of the day, after his night's feed. Shingles or pieces of boards answer fairly well for traps. When lettuce is troubled I have had the best success by using clear weak lime water, sprinkling the plants with the same, which in no way injures the lettuce, but is extremely distasteful to the slugs, evidently keeping them away, and they are destroyed if it comes in contact with their slimy bodies. It is claimed that cheap salt at

the rate of four or five bushels to the acre, or lime at the rate of ten or twelve bushels to the acre, applied twice in succession, will be instrumental in ridding soil of them. Salt is especially injurious to their mucous membrane. Fields should be dressed when slugs are active after heavy rain or in early morning before the sun is up; never during the hot part of the day or in very dry weather. Salt may be used sparingly in the flower garden. It should never be put close to plants for obvious reasons.

Moles in Lawn and Flower Beds: See page 163.

COTTONY MAPLE SCALE ON ELM AND MAPLE.

Fig. 164.—Cottony Maple Scale, *Pulvinaria inumerabilis*, on Soft Maple. Original.

Our illustration shows this insect, which has been extremely abundant this year, on soft maple. Maples and elms, as well as various vines and shrubs, in St. Paul, Minneapolis, St. Anthony Park and many towns throughout the state, as well as trees in localities in South Dakota and elsewhere, have been more or less affected. Its extreme abundance during the present season is not difficult to account for, since the wonderfully rapid rate at which

it increases, coupled with the fact that a number may have been present last year and yet not noticed, would account for its seemingly miraculous appearance last summer in enormous numbers.

The spreading from tree to tree could be affected, where trees interlace, by the active young crawling from limb to limb, and further by being carried on the feet of birds. In the opinion of the writer the English sparrow is, in a large measure, responsible for this, for he is pre-eminently now *the* bird of the city and village streets. We must not, however, overlook the agency of insects of various sorts, upon whose bodies the young lice could be easily transported. Prof. Riley, in the First Missouri Entomological Report, comments on this and says, "the copious secretion of honeydew attracts many honey loving insects, such as bees, wasps and flies, and these without doubt carry many of the restless young larvæ from tree to tree. "Spiders, too, are said to assist in this work, and even the beneficial "lady-bird" beetles which prey upon the scale. The wind too, in blowing infested leaves or twigs from one place to another, also plays a part in distributing this insect.

Ordinarily a strong, vigorous tree can withstand considerable sapping of this sort without being appreciably weakened, but when the pest is as abundant as it has been the past season, their pernicious work is bound to show, as indeed it did late in the summer, in the sickly appearance of some of the branches of the maples.

Remedies: If trees are trimmed in winter or early spring, and the cuttings burned, the adult scales on the cuttings, with many thousands of eggs, will be destroyed. The same result would be obtained by pruning and burning in the late summer and fall. Sprayings of kerosene emulsion in the spring and early summer will kill the young lice as they are crawling over branches and leaves, and strong caustic sprays, such as lye, or lime and sulphur, applied in the winter when the trees are dormant, will kill the adult scales and the contained eggs. Spraying a tall tree, however, is difficult and sometimes impossible. When but a few are present on a vine or shrub they may easily be got rid of with a bucket sprayer, or even killed by touching them with kerosene.

This scale has many natural enemies, both predaceous and parasitic, which unknowingly assist us in our work against it.

Life History: This scale belongs to the family *Coccidæ*, which contains all the scale insects, and its life history resembles in general that of other scales. Briefly, the young lice hatch in the spring and early summer, immediately migrate to the leaves, and temporarily become fixed. Sucking the sap from the leaves, they rapidly increase in size, moulting a number of times as they grow. The males undergo a metamorphosis, emerge from pupal case as minute two-winged insects, mate with the females and die; the impregnated females later migrate to the twigs and pass the winter fixed to the same. The following spring the developing eggs cause the body of the female to increase in size, and late in May and in June these eggs are laid in the cottony growth which the female has secreted at the posterior end of the body. In the above photograph the cottony (waxy) secretion is full of eggs. After laying from 1,000 to 2,000 eggs the female dies, probably in July.

The insect feeds not only on the trees above indicated, but upon various species of maple, upon wild grape, oak, basswood, hackberry, currant, locust, sumac, box elder, willow, woodbine (Ampelopsis), etc.

A LECANIUM ON CONIFERS AT THE STATION.

Fig. 165.—*Lecanium sp.* on Scotch Pine, showing whitish Coccinelled larvæ, *Hyperaspis*. Original.

For a number of years, so I am told by Prof. Green of the Horticultural Department, the above insect has been at work in the "forest" at the Experiment Station, and has caused the death of several Scotch Pines, *Pinus sylvestris*, though the horticulturist reports using 50 per cent kero-water with success. They were later found in large numbers on the Jack Pine, *Pinus divaricata*. At Prof. Green's request this department undertook to free the Scotch Pines from its attacks, and on July 11th these trees were sprayed with kerosene emulsion, one part emulsion to eight of water. On August 3rd they were sprayed again with the same strength, and the Jack Pines treated in the same way, this being the first treatment for the Jack Pines. Subsequent examination showed a marked decrease in the scales on the Scotch Pines, which received two treatments. In view of the presence of an immense number of larvæ and imagoes of the Coccinellid, *Hyperaspis*, which were feeding upon the scale, and which, naturally, suffered by the treatment meted the scale, we stopped further spraying. The white larvæ of the "lady bird," *Hyperaspis*, are shown in the accompanying cut among the scales.

THE STRIPED POPLAR BORER, MELASOMA SCRIPTA, FAB., AN ENEMY TO WINDBREAKS.

Fig. 166.—Poplar Borer, enlarged and natural size. A. G. Ruggles.

The above excellent illustration shows this beetle much enlarged and natural size. Complaint of its attacking poplars reached us

in May from Redwood County. It feeds upon the foliage of willow and poplar, and sometimes succeeds in almost defoliating these trees in windbreaks. Spraying with Paris green or any other arsenite will effectually stop their work. Fig. 167 illustrates the great variations in the markings of this species.

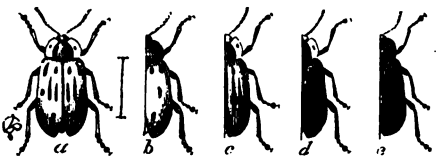


Fig. 167.—The Poplar Borer; variations from type. From Riley.

GALL MAKERS ON THE BOX ELDER, SOFT MAPLE AND BASSWOOD.

The accompanying illustration, Fig. 168, is from a photograph of box elder leaves, which exhibit a gall made by a tiny two-winged fly. For two years or more box elders, always attractive to many

Fig. 168.—Galls on leaves of Box Elder. A. G. Ruggles.

insects, have suffered from this pest. Our efforts to breed the fly from the gall have at last been successful, and the adult insect is shown in Fig. 169. The larva which comes from its egg lives within and helps form the gall, and is shown in Fig. 170. This fly, an expert in this group states, is probably *Cecidomyia negundinis*, Gill.

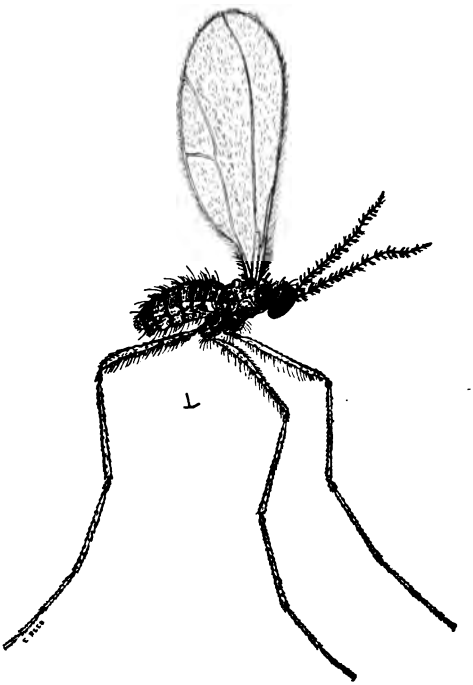


Fig. 170.

Fig. 169.—Fly bred from Box Elder Leaf Gall. Much enlarged. Original.
Fig. 170.—Maggot of Fly shown in Fig. 169. Much enlarged. Original.
The small line near the fly, as in other drawings in this report, shows the natural size of the insect.

Another tiny fly belonging to the same genus, *C. aceris*, Fig. 172, has this year affected soft maples, causing a rolling of the leaves, in which very imperfect gall lives the larva.

Two hymenopterous parasites, *Tetrastichus sp.* and *Meraporus sp.*, upon this fly were bred from the larvæ in our laboratory. Another parasite is shown in Fig. 173.

The work of this fly was first observed by us in July, and flies issued in our breeding jars the latter part of that month, between

Fig. 171.—Imperfect Galls on Leaves of Soft Maples. Original.

July 20th and 25th. On August 1st we found fresh galls containing larvæ on the maples, and assume from this and the date of emergence of flies in the breeding jars that this represents another brood of maggots, possibly the second. Maggots were found at

Fig. 172.—Fly Raised from Galls in Soft Maple Leaf. Much enlarged. Original.

work on the maples as late as August 25th. Later examinations, September 4th, failed to disclose any eggs, larvæ or pupæ, and the work of the fly had evidently stopped for the season. I believe we are safe in stating that there are at least two broods of this fly in this locality.

Both of these flies belong to the family of gall-making gnats known as *Cecidomyiidæ*. In it are found some of the most destructive insects, the Hessian fly, for example, the Wheat Midge, Willow Gall Flies, etc.

It is doubtful if any remedy is practical for the injury caused by these insects, beyond the picking off and destruction of affected leaves containing the larvæ, if the trees are small and few in number. Some repellant solution might possibly be sprayed on leaves frequently during the season of the insect's attacks, and be more or less effective. The gall-like growths caused by many flies in this and other gall-making families—said growths being seen in

Fig. 173.—Four-winged Parasite, reared from maggots of Fly shown in Fig. 172. Original.

willow, oak, golden rod, sumac, maple and countless other trees and plants—are caused by the tissue of the plant in the immediate vicinity of the egg or larva making an abnormal growth, due evidently either to the presence of an irritating agent placed there by the parent insect, or by a secretion from the newly hatched larva, or in some other way not at this time thoroughly understood. Two hundred years and more ago it was believed that these growths on plant, bush or tree were vegetable productions, and that the "worms" found therein had arisen spontaneously.

We have also reared this year *Cecidomyia robiniæ*, Hald., from galls on leaves of Locust, *Robinia*. From this latter gall fly we raised a four-winged parasite belonging to the group *Peromalinæ*. A Washington expert in this sub-family informs us that it represents apparently an undescribed genus.

The Basswood here are always more or less affected with galls on leaf and fruit as represented in Fig. 174. Fig. 175 represents one of the galls opened showing two larvæ inside, and Fig. 176 a

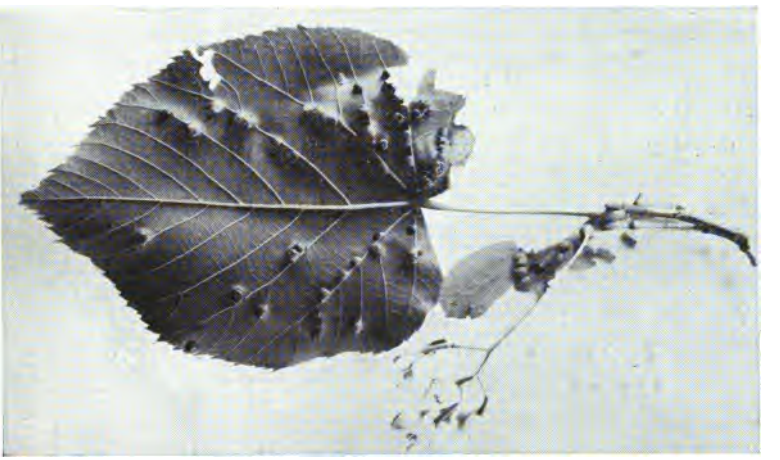


Fig. 174.—Basswood Leaf and Fruit, showing Galls. Original.

larva much enlarged. We have not yet reared the fly and hence hesitate to name it. It belongs to the same family, *Cecidomyiidæ*, as the gall flies in box elder, maple, and locust discussed above.

Fig. 175.

Fig. 176.

Fig. 175.—Gall of Basswood enlarged, showing maggots within. Original.
Fig. 176.—A Maggot shown in Fig. 175, much enlarged. Original.

FUMIGATION FOR THE VIOLET GALL FLY, *DIPLOSIS VIOLICOLA*, COQ., AND FOR THE BLACK OR BROWN APHIS OF VIOLETS, *RHOPALOSIPHUM VIOLÆ*, PERG.

During the Entomologist's absence from the office in September, his assistant, Mr. Ruggles, answered a call in St. Paul, from a

lady who was troubled with the above pests in her greenhouse. The Violet Gall is caused by the larva of a small two-winged fly, which rolls up a violet leaf and lives within. Rotting of the leaf is apt to follow this imperfect gall.

Mr. Ruggles first accurately determined the cubic contents of the greenhouse, and then fumigated with hydrocyanic acid gas at the rate of 0.15 grams (2,325 grains) to a cubic foot of space. The cyanide of potash, sulphuric acid and water were used in the proportion of 1-1½-2, and the exposure was 35 minutes. As results proved, 25 minutes, the prescribed time, would perhaps have been better, since some of the more tender growth was injured.

Some of the Aphids survived the above treatment, though many perished. The insects causing the galls were apparently killed, though the difficulty appeared after the above treatment, calling for a second application.

GRAIN PLANT LOUSE.

A few reports of the occurrence of this insect have been mailed the Experiment Station by parties who were somewhat alarmed at seeing them on heads of wheat. As usual, they have been taken care of by parasites, and their presence has resulted in no serious harm.

Fig. 177.—Grain Plant Lice from which parasites have issued.

INTRODUCTION.

This bulletin gives some of the results of investigations relating to the fertility of soils, conducted by the division of agricultural chemistry of the Minnesota Agricultural Experiment Station. The results are presented in three articles. In the first article "The Influence of Crop Rotations and Farm Manures upon the Humus Content and Fertility of Soils," it is shown that when grains are grown continuously there is a heavy loss of nitrogen from the soil, caused by decay of the humus of which nitrogen is one of the component parts. When grains are grown in a rotation with clover, and farm manures are applied to the corn crop, the losses of nitrogen and humus are reduced to a minimum and the crop producing power of the soil is increased.

The second investigation, "The Water Soluble Plant Food of Soils," shows the extent to which plants can utilize the mineral food dissolved in the soil water. When wheat, oats and barley were supplied only with soil leachings they failed to make a normal growth and to produce seeds, showing that water alone acting upon a fertile soil is not sufficient to supply a crop with its mineral food but a large part is taken in other forms and that it is necessary for the farmer by means of cultivation, manures and rotation of crops to increase the reserve plant food of the soil, not soluble in water, so as to secure maximum yields.

The third investigation, "The Production of Humus in Soils," shows the extent to which the proteid compounds of food stuffs and manures combine with the inert phosphoric acid and potash of the soil to form compounds known as humates. The loss of nitrogen during the process of humification is considered and also the form in which the nitrogen exists in humus. The action of farm manures and crop residues upon the inactive mineral matter of the soil to form humates and the value of humates as plant food and as a factor in soil fertility are also discussed. The three articles of this bulletin discuss some of the phases of the problem of soil fertility particularly the part which farm manures and rotation of crops take in the maintenance of fertility.

THE INFLUENCE OF CROP ROTATIONS AND FARM MANURES UPON THE HUMUS CONTENT AND FERTILITY OF SOILS.

HARRY SNYDER.

In 1892, an investigation was undertaken to determine the influence of crop rotation and farm manures upon the humus content and fertility of soils. Six adjoining plots of uniform crop producing power were selected for experimental purposes. The soil had previously been under cultivation for about forty years and had produced mainly wheat and other grains without the use of fertilizers. The soil was in a fair state of fertility, but somewhat improverished from continuous cropping. The first year, all of the plots were sown to the same crop to determine if the soils were uniform in crop producing power, and it was found that they were; the greatest difference in yield between any of the plots being 1.10 bushels of wheat per acre. At the beginning of the experiments, samples of soil from each of the six plots were taken for analysis.

On four of the plots, wheat, oats and barley were grown continuously and without the application of any manure. On two of the plots, a rotation including clover, wheat, corn, oats and barley was followed, and farm manures were used.

In former bulletins of this station (Nos. 53 and 70) reports are given regarding the effects upon the fertility of these soils of continuous cropping and rotations for the first and second four year periods. This bulletin gives a brief report of the third period, 1900-4 inclusive, and a summary of the effects upon the fertility of twelve years continuous cropping compared with crop rotations and the use of farm manures.

It is to be observed in the case of four of the plots, those upon which wheat, corn, oats and barley were grown continuously, that no humus forming materials were added, while on two of the plots the use of farm manures and clover added humus to the soil. During the time of these experiments, 1892-1904, a variety of climatic conditions were ex-

perienced. In the early part of the experiments, there were three years of light rainfall while during the latter part there were three years of excessive rainfall. A study of the moisture content of these plots was made during one wet and one dry season. The influence of continuous cultivation, rotation of crops and application of farm manures upon crop yields and upon the humus and nitrogen content of these soils is quite noticeable and is briefly discussed in this bulletin. The cultivation of the plots, including the plowing, seedng, harvesting and weighing has been carried on by the Division of Agriculture and to that division credit is due for assistance rendered in this investigaton.

The plot upon which wheat has been grown continuously produced as low as 8.9 bushels in 1894 under adverse climatic conditions, and as high as 25.2 bushels in 1898. At the beginning of the experiment, the soil contained about 7,700 pounds of nitrogen per acre to the depth of one foot. During the first eight years there was a loss from this plot of 21.7 per cent, or 1,600 pounds of nitrogen per acre. The loss during the last period of four years was proportionately less than in either of the former periods; while 21.7 per cent of the soil nitrogen was lost during the first eight years of continuous wheat culture, only 5.71 per cent was lost during the four following years. In earlier investigations, it was shown that the heaviest losses of nitrogen from the soil occur during the earlier periods of cultivation and the longer a soil is under exclusive wheat cultivation, the less proportionally are the losses of nitrogen. In earlier investigations it was shown also that the humus of the soil is changed in chemical composition by continuous cropping; the loss of nitrogen results in the formation of humus containing more carbon and less nitrogen—a humus having more of the characteristics of charcoal, and presumably a less active form.

While this soil shows a loss of 2,039 pounds of nitrogen in the twelve years of continuous wheat cultivation, the crops have removed less than 450 pounds during that time, indicating that nearly 1,600 pounds have been lost mainly through the decay of the humus and liberation of the nitrogen. For every pound of nitrogen removed by the wheat crop, there has been a loss of over four pounds from the soil by the decay of the humus.

Nitrogen is one of the elements of which humus is composed and a loss of humus entails a loss of nitrogen which is one of the most valuable elements of plant food and is utilized for the production of wheat gluten and other proteids. The

humus in this soil contained about 10 per cent of nitrogen. That the loss of nitrogen has been due to the decay of the humus is shown by the analysis of the soil. During the twelve years of continuous wheat cultivation the soil has lost about ten per cent of its volatile or combustible matter. The humus determinations also show a corresponding loss. While the methods employed for the determination of humus do not admit of the same degree of accuracy as in the case of nitrogen, a loss of both volatile matter and humus followed by a slight change in the composition of the humus, particularly its nitrogen content, points conclusively to the decay of the humus as the cause of the loss of nitrogen from the soil.

The loss of nitrogen from the soil when wheat is grown continuously is excessive, and this loss is one of the causes why soils decline in fertility and produce lessened yields when continuous wheat farming is attempted.

On plot number two, a rotation consisting of wheat, clover, wheat, oats and corn and manure, has been followed with some modifications because of climatic conditions. The soil of this plot contained originally about the same amount of nitrogen as plot No. 1, namely, 7,700 pounds per acre to the depth of one foot. At the end of twelve years, the soil contained 6,725 pounds; during the first eight years, the loss amounted to 800 pounds and during the last four years, to 175 pounds, a total loss of about nine per cent. Compared with the plot upon which wheat was grown continuously, it is to be noted that there was a saving of over a thousand pounds of nitrogen as a result of the rotation of crops and dressing of farm manure every five years.

The humus content of the soil of plot number two has been practically maintained by means of the rotation including clover which has been practiced, and by the use of farm manure on the corn crop. The soil contained originally about 3.3 per cent of humus and at the end of twelve years, 3.4 per cent. In plot number one which has produced twelve wheat crops in succession, the soil contains less than three per cent of humus, while originally there was the same amount as in plot number two. When wheat is grown continuously, the loss of humus is quite noticeable, while in a rotation such as was followed in the case of plot number two, this loss of humus is checked, and an equilibrium is established in the soil, the losses from decay being replenished by the clover, and farm manure. This maintenance of the humus, and minimum loss of nitrogen are noticeable in their effects upon fertility as measured by crop yields.

From plot number two which has produced crops in rotation there has been a larger amount of nitrogen removed by the crops than in the case of plot number one where wheat has been grown continuously. While approximately 450 pounds of nitrogen have been removed in twelve wheat crops, over 800 pounds have been removed in the various crops grown on plot number two, showing that while the loss of nitrogen has been reduced to a minimum by the rotation of crops, the soil has actually supplied a larger amount for their production. A rotation conserves the nitrogen of the soil and enables more nitrogen to be used economically by crops without depleting the soil than when one grain is grown continuously.

On plot number three, oats, clover, barley and corn (manured) have been grown in rotation. It is to be noted in this rotation that clover is grown once in four instead of once in five years as on plot number two. These rotations are not given as model rotations but are simply types which were selected for experimental purposes with the view of determining the influence of these crops upon the nitrogen content and fertility of the soil. The soil of plot number three originally contained about 7,400 pounds per acre of nitrogen. At the close of the first period of four years, the soil showed a slight gain in nitrogen, and at the end of eight years, a slight loss. During the third four-year period also there was a slight gain of nitrogen, and at the end of twelve years, the soil contained about 7,800 pounds per acre, showing that where clover was grown once in four years in a rotation with grains, and one dressing of farm manure was applied to the corn at the rate of eight loads per acre, the nitrogen content of the soil has been maintained unimpaired. There was also an appreciable gain in the humus content of the soil. The soil originally contained about 3.30 per cent of humus and at the end of twelve years 3.7 per cent. It is evident that the growing of clover every four years and the application of farm manure to the corn crop has enabled the soil to increase its stock of humus. The increase of nitrogen and humus in the soil has been followed by increased crop yields. When wheat was grown in a rotation after clover there was a gain of from five to six bushels per acre, and when corn was grown in rotation there was an increase of over twenty bushels per acre compared with the plot which produced corn exclusively. Barley and oats also show increased yields when grown in rotation. These increases in crop yields are undoubtedly due to the

maintenance of the nitrogen and humus content of the soil and to the chemical action of the humus upon the mineral matter of the soil in rendering plant food available as well as due to improved physical condition of the soil and to a more uniform water supply because of the increase in humus.

The action of decaying animal and vegetable matter upon the soil and the formation of available plant food through humification is discussed in another article in this bulletin.

The differences in nitrogen content of the sub-soils from the rotated and the continuously cropped plots are noticeable. The sub-soil of plot number 1 (continuous wheat) contains .094 per cent of nitrogen, while the sub soil from plot number two (rotation) contains .127 per cent, a difference of about 1,200 pounds in favor of the rotated plot. When corn, oats and barley were grown continuously, the sub-soil contained .093, .105 and .098 per cent respectively, of nitrogen. The decrease of nitrogen when wheat, oats, barley and corn were grown continuously was not alone confined to the surface soil but proportionally as much nitrogen was lost from the sub-soil as from the surface layer. When crops are rotated the sub-soil as well as the surface soil nitrogen is conserved.

On plot number four corn was grown continuously. During the twelve years the soil lost 1,400 pounds of nitrogen, about 18 per cent of the total amount originally present. The loss of nitrogen was less when corn was grown than when wheat was grown continuously. Although a corn crop removes more nitrogen from the soil than a wheat crop, there appears to be less lost from the soil when corn is grown than when wheat is grown. It is possible that this may be due to the corn crop occupying the land during the late summer and for a longer time than is the case with the wheat crop. When corn is grown continuously, the losses of both humus and nitrogen from the soil are excessive and these losses can be checked by practicing a suitable rotation in which clover forms a part and farm manures are used.

When oats and barley were grown continuously on separate plots, (Nos. 5 and 6) the losses of nitrogen and humus were about the same as when wheat was grown continuously. The average losses from the two plots, Nos. 5 and 6, were about 2,000 pounds per acre for the twelve years; 25 per cent being removed by the crops and about 75 per cent lost by decay of the humus and liberation of the nitrogen.

It is quite evident when any crop, as wheat, corn, oats or barley, is grown continuously that the losses of nitro-

gen are large and that these losses can be either reduced to a minimum or checked by growing the same crops in rotation with clover and using farm manures.

YIELDS PER ACRE OF GRAIN GROWN CONTINUOUSLY.

Year.	Plot 1 Wheat bu.	Plot 4 Corn bu	Plot 5 Oats bu	Plot 6 Barley bu
1893	12.3	50	42.5	28
1894	8.9	33.3	27	18.5
1895	17.3	75.5	54.1	39
1896	14.1	44.4	31	35.6
1897	10.2	10	31	28.1
1898	25.2	30.5	56.2	40.3
1899	17.6	...	24.7	26.7
1900	18.8	42.2	11.2	2.6
1901	16.2	37.8	52.5	29.2
1902	18.3	...	52.5	28
1903	18.6	33.3	58	30
1904	13.7	22	47.5	33.3

YIELDS OF ROTATION PLOTS.

Year	Plot 2.		Plot 3.	
1893	Wheat, bu	13.7	Oats bu	46.1
1894	Clover, lbs 4,320		Clover, lbs 2,360	
1895	Wheat, bu	22	Barley, bu	42.5
1896	Oats, bu	31.4	Corn, bu	66.7
1897	Wheat, bu	14.2	Corn, bu	33.7
1898	Clover, lbs 2,820		Oats, bu	76.4
1899	Wheat, bu	19.5	Clover lbs 3,720	
1900	Wheat, bu	24.4	Barley, bu	28.3
1901	Oats, bu	58.7	Corn, bu, ...	40.6
1902	Corn, bu	....	Oats, bu	80
1903	Wheat, bu	30	Clover, tons	4.7
1904	Clover, tons	3.98	Barley, bu	40

THE WATER SOLUBLE PLANT FOOD OF SOILS.

HARRY SNYDER.

In order to determine the extent to which the water soluble plant food of soils contributes to plant growth, a series of experiments were undertaken in which the only food supplied was in a soluble condition and was obtained by leaching a fertile soil. Sterile sand was prepared by treating pure white sand with dilute acid, washing with distilled water and then igniting. The sand was tested and found to give a neutral reaction. In order to guard against any possibility of free acid being retained by the sand, a small amount, 100 milligrams per kilogram of soil, of calcium carbonate was mixed with the sand.

Four pots of sand were prepared in this way and seeded respectively to oats, barley and wheat; two pots being seeded to wheat. Pots of the same size were filled with fertile soil from one of the experimental plots which had yielded 30 bushels of wheat per acre and was in a high state of fertility. No plants were grown in these pots but they were leached from time to time during the growing season with distilled water and the leachings were used for supplying water soluble food to the plants seeded in the prepared sand.

In another series of pots filled with the fertile soil, wheat, oats and berley were seeded. The pots in which no plants were grown but which were leached to supply the water soluble plant food furnished to the plants grown in the prepared sand, were treated so as to secure the largest possible amount of soluble plant food. The soils were aerated from time to time and the leaching discontinued for a few days, then followed by leaching again.

The plants seeded in the pots containing the fertile soil made a normal growth, produced seed and a good yield of straw and dry matter. The plants seeded in the sand and watered with the soil leachings, at the end of two weeks, showed signs of disturbed nutrition, the tips of the leaves began to die and new growth was followed by portions of former growth drying up and dying. The plants, about six weeks after seeding, had made the total growth shown in Plate No. 1, while the plants seeded in the fertile soil had made the growth as shown.

From the photographs, it is evident that the plants fed upon the soil leachings made but limited growth compared with those grown in normal soil. A few days after the photographs were taken, which was a little more than six weeks

after seeding, the wheat plants died down completely and failed to make any renewed growth. About half of the barley plants also died and the few which remained alive were sickly in appearance, dwarfed in size and just barely managed to live. The barley gave no signs of heading out. The oats made a somewhat better showing than the barley. Two of the oat plants headed out and produced hulls but no seed was formed, the grain simply refused to fill out.

The plants were supplied regularly with the soil leachings, and at no time was there a lack of moisture in the soil, in fact, the plants grown with the soil leachings received a larger amount of water than those grown in the normal soil. The wheat plants fed upon the soil leachings made a better showing than those watered with distilled water, which died about six weeks after seeding. (See Pot 1 Plate I.)

The sand used in this investigation was prepared by Mr. J. A. Hummel, Assistant Chemist, who did part of the analytical work. Mr. Ralph Hoagland also assisted in the analytical work.

When this expcriment was outlined, it was planned to pass the soil leachings through a Pasteur-Chamberland filter so as to remove all suspended particles and to supply only the compounds which were soluble and not materials that might be in suspension in the soil leachings. This plan was abandoned as it was feared that the leachings would then be perfectly sterile, which would exclude the necessary soil organisms and possibly introduce an uncontrollable feature into the experiment. The leachings were prepared by passing the soil solution through a double folded filter. The leachings were reasonably clear, but occasionally the presence of suspended matter in the filtered solution could be observed. This, however, was disregarded and was considered as soluble plant food slightly increasing the amount of nitrogen, phosphoric acid and potash in the soil leachings over what was in solution. That is, the plants received not only the soil leachings but a small amount of suspended fine earth particles which failed to filter out in the preparation of the soil solution. The sand was fine in texture and in the best physical condition for culture experiments. In previous investigations, sand similar in character had been used and when all of the elements of plant food were supplied, normal plants were produced which reached maturity. The failure of the plants to complete their growth when seeded in the prepared sand and watered with the soil leachings was plainly not due to any adverse physical condition.

The plants were kept out of doors most of the time. In the case of light showers, they were left exposed but in case

of heavy showers and wind storms when it was feared that injury might be done to them, they were brought under shelter. The plants grown in pots of fertile soil were exposed out of doors from the beginning as they were sufficiently hardy and vigorous to stand slightly adverse conditions as the heavy wind and rain storms which were very frequent. The last photograph was taken after the plants had been exposed to a heavy storm which did much damage.

It is quite evident that the soil leachings failed to supply a sufficient amount of plant food to produce normal plants of wheat, oats and barley, as the plants grown in prepared sand and watered with the soil leachings were sickly in appearance, stunted in growth and failed to produce any seeds. It is also evident that the plants grown in the pots of fertile soil obtained a large portion of their food from forms which are insoluble in water.

During the progress of the experiments, an aliquot portion of the leachings was saved and evaporated to dryness forming a composite sample. These leachings at the close of the work were analyzed and the total amounts of nitrogen, phosphoric acid and potash determined. The plants grown in prepared sand and watered with soil leachings, also those grown in fertile soil were analyzed at the close of the experiment and found to contain the following amounts of dry matter, nitrogen, phosphoric acid and potash:

TABLE I.

	Grams of Materials per Litre of Soil Leachings.
Nitrogen	.03125
Phosphoric Acid	.00937
Potash	.0500

TABLE II.

	Grams of Materials in Crops					
	Watered with Soil Leachings			Grown in the Normal Soil		
	Wheat	Oats	Barley	Wheat	Oats	Barley
Number of plants	16	16	12	16	16	12
Dry matter	2.14	4.833	6.15	7.05	8.656	11.75
Nitrogen	*	*	*	.1537	.1424	.2639
Phosphoric Acid	.	.0396	.0320	.0534	.1374	.086
Potash	*	.1063	.0836	.1661	.2084	.2115

* Sample too small for analysis.

1. 2. 3. 4.

Fig. 1. Pots 2, 3, 4, grains grown in White Sand and Watered with Soil Leachings. Six Weeks After Seeding. Pot 1. Watered with Distilled Water.

Fig. 2. Grains grown in Normal Soil. Six Weeks after Seeding.

PLATE I.

Fig. 3. Grains grown in White Sand and Watered with Soil Leachings.

Fig. 4. Grains grown in Normal Soil.

PLATE II.

The plants grown in pots of normal soil produced in the aggregate over twice as much dry matter as those grown in pure sand and watered with soil leachings. In the case of the wheat, the soil leachings produced too small a crop to allow the duplicate ash analysis to be made. The oat plants grown in sand and supplied only with water soluble plant food in the form of soil leachings contained about a fourth as much phosphoric acid and half as much potash as an equal number of oat plants grown in normal soil. The same general results are observed in the case of the barley where the plants grown in pots of normal soil contained about two and a half times more potash and 2.7 times more phosphoric acid than barley fed on the soil extract. It is quite evident that soil leachings fail to furnish a sufficient amount of available plant food to produce a normal crop of wheat, oats or barley, as none of the plants fed upon the soil leachings produced seeds. The plants forced to obtain all of their food from water soluble forms as soil leachings assimilated only a quarter to a third as much phosphoric acid and potash as those grown in normal soils.

The plants grown in prepared sand were supplied with an abundance of water in the form of soil extract, in fact, more than under normal field conditions. Ten litres of soil leachings were supplied to each pot and produced from 2.14 to 6.15 grams of dry material. According to Hellreigel's investigations, one part by weight of dry matter should be produced from 300 parts of water. In these experiments from six to eighteen times more water as soil extract was supplied than is required to produce a crop under normal field conditions. But notwithstanding this excess of water in the form of soil leachings the plants refused to produce seeds.

To produce 5 grams of dry matter, according to Hellreigel, would require about 1,500 grams of water, which in the form of soil extract would contain about .013 grams of phosphoric acid. Five grams of oats fed on the soil extract contained .029 grams of phosphoric acid, indicating that the oat plant has some power to select its food and can assimilate from water soluble forms more than is dissolved in the soil water lost by transpiration. This selective power, however, is not sufficient to furnish the plant with a normal supply of available plant food, inasmuch as the plants grown in normal soil contained over four times as much as the oat plants fed on the soil leachings.

In a former paper (1), it was concluded that if the total water required by a wheat crop were furnished in the form of a saturated soil solution, less than 20 per cent of its phosphoric acid would be supplied in water soluble forms.

In these experiments where the only form of phosphoric acid was that supplied in soil leachings, less than 25 per cent of what is present in an oat crop grown on normal soil, was assimilated by the oat plants supplied with the soil leachings. It is evident that in the case of phosphoric acid the soil solution was too dilute to furnish a sufficient amount.

To the farmer these results are significant as they mean that water alone coming in contact with a soil of high fertility is not the only factor necessary to render plant food available and to promote crop growth, as the crop itself exerts a definite solvent power in rendering its food soluble provided the food does not exist in the soil in too inert forms. The water soluble plant food of the soil supplies to a grain crop as oats, wheat or barley, only a small part of its mineral food. Farm manures, judicious cultivation, rotation of crops, production of legumes, and in some cases amendments must be resorted to in order to bring about the initial changes in the soil that convert the inert plant food into a condition to be utilized by crops but not necessarily into water soluble forms.

(1) The Water Soluble Plant Food of Soils. Proceedings of the Soc. for the Promotion of Agr. Science, 1903.

THE PRODUCTION OF HUMUS IN SOILS.

HARRY SNYDER AND J. A. HUMMEL.

In former bulletins, numbers 30, 41, 53 and 67, of this station, are given results of investigations upon the production of humus from decaying animal and vegetable matter and the value of humus as a factor in soil fertility. In these investigations, it was shown that when farm manures and crop residues decay, chemical products are formed which unite with the mineral matter of the soil and produce substances known as humates, (1) and that these organic salts are capable of being utilized as food by farm crops. Wheat, oats and barley were grown where the only source of mineral food was that combined with the humus. Since humus takes such an important part in soil fertility and through its decay products are formed which make the mineral matter of the soil more available and valuable as plant food, thereby increasing the yield of crops, it has been deemed advisable to continue the investigations relating to humus and its chemical action upon the soil.

When vegetable substances, such as cellulose or woody fibre, starch and albumin, decay, there are a number of different products formed from each, many of which are capable of uniting with some form of the mineral matter of the soil. In the absence of the right kind of basic material, the humus produces sour acids such as are found in many swampy and peaty lands. Even in well drained upland soils, the humus may produce organic acids owing to lack of suitable mineral matter for neutralizing the acids formed during the decay of manures and other forms of vegetable and animal matter.

No exhaustive study has yet been made of the organic compounds formed by the union of the soil bases with the organic matter of manures and crop residues and known as humates. Humates are difficult to separate from the soil; they do not form well defined crystallized bodies, and many of them are unstable, hence our knowledge regarding their properties is limited. It is believed, however, that the subject is of sufficient importance to merit the serious attention of

(1) Minn Agr. Ex. Sta. Bul. 41, pp. 14-16, Bul. 53, pp. 12-17.

organc chemists, as many orgenic compounds of the soil remain to be discovered, to say nothing of the economic importance of these bodies in relation to soil fertility.

The use of farm manures, green manures tnd crop residues for maintaining and increasing the fertility of soils through the agency of humus has been resorted to by tillers of the soil from the earliest times, and it is without doubt one of the most natural, economic, and practical ways of maintaining the fertility of the soil.

Farm manure is a mechanical mixture of the indigestible or unabsorbed substances in food stuffs mixed with straw or some form of litter. In order to determine the chemical action upon soils of each class of compounds of which manures are composed such as indigestible protein, cellulose, carbohydrates and the various derivatives of these compounds, each requires separate consideration.

HUMUS—PRODUCTION EXPERIMENTS.

The plan which has been followed in this and former investigations was to take a definite weight of soil poor in humus as a sub-soil, and mix with it a weighed amount of some animal or vegetable substance and allow the process of humification to take place out of doors for a year or more. This method produces humus and humates of known origin and allows reasonably definite determinations to be made of the extent to which animal and vegetable matter may combine with the minerals in the soil in the formation of humus.

On July 24, 1901, a number of boxes of subsoil similar to that used in other investigations (Bulletin No. 53) were mixed with casein, albumin, wheat gliadin and other compounds; in some of the boxes known amounts of mineral substances were also added. The boxes were exposed out of doors for one year to allow humification to take place. Previous to exposure, samples of the soil and of the various organic substances used were analyzed and after the close of the year they were again weighed and analyzed. The results of this work of humus production are briefly recorded in the following pages.

In one of the boxes, seventy-five grams of gliadin, which is one of the proteids of wheat gluten, and two thousand grams of soil were placed and allowed to undergo humification for one year. Wheat gliadin was used as it is a type of insoluble proteid found in farm grains, and also in farm manures as a product of digestion.

COMBINATION OF HUMUS WITH PHOSPHATES OF SOIL.

The soil used contained .76 per cent of humus, as determined by the official method of the Association of Agricultural Chemists. The humus contained phosphoric acid to the extent of .042 per cent. on the basis of the total soil. The phosphoric acid content of the gliadin, .28 per cent, was considered as in organic combination, and was calculated as capable of forming humic phosphates. At the beginning of the experiment, the soil contained .84 grams of phosphoric acid in combination with the humus and when added to that in the gliadin, .215 grams, there was a total of 1.055 grams phosphoric acid in the soil combined with the humus and the gliadin. At the end of the year, the box weighed 2,040 grams and yielded a humus with .06 per cent of phosphoric acid, equivalent to 1.22 grams, a gain of .165 of a gram. This addition of 15.57 per cent of phosphoric acid to the humus was from the insoluble phosphoric acid of the soil as there was no other source from which it could be obtained. The gliadin in its decay evidently combined with some of the phosphoric acid of the soil.

In another box, 80 grams of gliadin, two grams of calcium carbonate (limestone), and 2,000 grams of soil were given a similar exposure for one year. At the beginning of the experiment, the box contained 1.06 grams of humic phosphates, and at the end of the year, 1.18 grams, showing a gain of .12 grams or 11.32 per cent.

As a check upon the work similar boxes containing pure white sand in place of soil were used and from these boxes less humic or ammonia soluble phosphoric acid was obtained at the close of the year than was present in the original humus forming materials, showing that when decay takes place in the absence of soil, there is a loss of phosphoric acid in humic forms.

In a previous investigation, Bulletin 53, page 19, flour and soil were allowed to undergo humification and as a result .12 grams or nearly twenty per cent of phosphoric acid was added to the humus.

From these experiments, it is reasonable to conclude that an insoluble proteid as gliadin, when it undergoes decay in presence of soil, has the power of combining with an appreciable amount of the mineral phosphates of the soil.

In addition to gliadin, a number of seperate trials were made with egg albumin and soil, egg albumin and limestone,

egg albumin and potassium sulphate and egg albumin and sand. Egg albumin was selected as a type of the soluble proteids. While it is not liable to be present as albumin in manure, the albumin in its decay produces compounds as amides similar to those formed from the indigestible proteids of manure or from an insoluble proteid as gliadin. The results of these experiments are given in the following table:

TABLE I.—Production of Humates and Absorption of Soil Phosphates by Humus.

Box No.	Soil Used	Albumin Used	Salts Added	Humic Phosphoric Acid			
				In Original Box	At Close of Year	Grain	Grain
	Grams.	Grams	Grams	Grams	Grams	Grams	Per Cent.
3	2000	80	.....	1.01	1.11	.10	9.9
4	2000	80	.Calcium Carbonate.	1.01	1.10	.09	8.9
6	*Sand.	80	..Potassium Sulfate.	1.01	1.11	.10	9.9
13	2000	100	.....Ferrous Acetate.	.28	.22	.06	21.4
17	2000	80	.....Iron Succinate.	1.01	1.25	.24	23.7

When albumin was allowed to decay in contact with soil, there was an addition to the humus of .10 grams of phosphoric acid derived from the soil. When calcium carbonate and potassium sulphate were added to the soil they did not appear to materially affect this process of fixation of soil phosphates by the humus. When sand was substituted for soil, there was a loss of .06 grams of phosphoric acid from the humus. It is evident that albumin in its decay in contact with soil exerts a similar influence to that of the wheat proteid gliadin and combines with a similar amount of phosphoric acid.

In order to determine the extent to which the additon of phosphoric acid to humus could take place, four grams of sodium phosphate were added to box No. 5 containing 2,000 grams of soil and 80 grams of egg albumin. The soil and egg albumin contained 1.01 grams of humic phosphoric acid, 1.44 grams were added as sodium phosphate. At the end of the year, the soil yielded a humus with 1.79 grams of phosphoric acid, showing that a little over half of the phosphoric acid of the sodium phosphate had united with the humus. In another box, No. 18, 70 grams of egg albumin, 3 grams of sodium phosphate, 5 grams of iron succinate, and 3 grams of potassium carbonate were added to 2,000 grams of soil. At the beginning of the experiment, the humus and albumin contained .987

grams phosphoric acid and at the close 1.61 grams, indicating that about .6 grams of phosphoric acid had been gained from the sodium phosphate. From these experiments, it is evident that humus is capable of combining with quite large amounts of soluble phosphates in addition to those present in the soil. This is in accord with the well known law of fixation as shown by the investigations of Way and others.

When a proteid is used which is already saturated with phosphorus compounds, it is not capable of uniting with any additional amount but undergoes decay with liberation of phosphoric acid. This was observed in the case of commercial casein which contained 3.01 per cent of phosphoric acid, while gliadin and egg albumin each contained less than a tenth as much. When commercial casein was allowed to undergo decay in contact with soil, there was no fixation but a liberation of phosporic acid from the humus. Eighty grams of casein containing 2.48 grams of phosphoric acid when added to the humic phosphoric acid of the soil, .84 grams, yielded at the end of the year, a humus with 1.97 grams of phosphoric acid, a loss of 1.35 grams.

It is to be noted that in the experiments where casein was used, the resultant humus contained 12.67, 11.64 and 11.20 per cent respectively of phosphoric acid, while that produced from egg albumin and sodium phosphate contained 10.11 per cent. It is evident that the humus formed from commercial casein is already saturated with phosphoric acid and is not capable of uniting with any of the soil phosphates. A humus with 12 per cent of phosphoric acid and present in a soil to the extent of 4 per cent is equivalent to about .09 per cent of phosphoric acid on the basis of the total soil. Frequently, as noted in former bulletins, a rich prairie soil is found containing 4 per cent of humus with .09 per cent and more of phosphoric acid combined with the humus. In such cases the humus is practically saturated with phosphoric acid.

The exact nature or form of combination of the humus with the phosphoric acid of the soil has not as yet been determined, other than the fact that the proteids in forming humates are not able to combine with or fix more than 12 per cent of their weight of phosphoric acid.

That a combination takes place is evident from the number of facts. After the formation of the humus, the phosphoric acid of the soil was appreciably more soluble in dilute ammonia such as is used in the extraction of the humus, and while all of the phosphoric acid thus extracted may not have been in direct combination with the humus, it is evident that

the humus influenced its composition sufficiently to affect the solubility which is the direct result of a chemical change. When the humus extract is passed through a semi porcelain filter, the phosphoric acid is still present and when precipitated with acids, washed and redissolved, the phosphoric acid is not removed, showing that as the result of the process of humification, the phosphoric acid enters into chemical combination with the humus.

TABLE II.—Action of Proteids upon Soils in Humus Formation

Box No.	CONTENTS	Humus	Nitrogen Content of Humus.	Humic P_2O_5.	Total Nitrogen
		P. Ct.	P. Ct.	P. Ct.	P. Ct.
1	2 kilos, soil, 75 gms. gliadin	.84	5.49	.06	.20
2	2 kilos, soil, 80 gms. Gliadin, 2 gms calcium carbonate	.86	6.00	.06	.20
3	2 kilos, soil, 80 gms. egg albumin	.90	6.67	.05	.22
4	2 kilos, soil, 80 gms. egg albumin, 2 gms. calcium carbonate	.86	6.32	.053	.15
5	2 kilos soil, 80 gms. egg albumin, 4 gms. sodium ammon. hydrogen phosphate	.86	5.89	.087	.15
6	2 kilos. coil, 80 gms. egg albumin, 4 gms. potassium sulfate	.81	7.80	.052	.17
7	2 kilos. soil, 80 gms. casein	.76	5.84	.096	.12
8	2 kilos. soil, 80 gms. casein, 2 gms. calcium carbonate	.80	5.69	.093	.12
9	2 kilos. soil, 80 gms. casein, 4 gms. sodium ammon. hydrogen phosphate	.85	6.92	.096	.14
10	2 kilos. soil, 80 gms. casein, 4 gms. potassium sulfate	.91	6.04	.092	.12
11	2 kilos. sand, 100 gms. casein, 10 gms. iron carbonate	.34	5.31	.022	.....
12	2 kilos. sand, 100 gms. casein, 10 gms. calicium carbonate	.39	5.29	.016	.....
13	2 kilos. sand, 100 gms. egg albumin, 10 gms. iron acetate	.37	7.40	.011	.....
14	2 kilos. sand, 100 gms. casein, 10 gms. iron lactate	.37	5.82	.02	.....
15	2 kilos. sand, 100 gms. casein, 10 gms. potassium carbonate	.37	5.93	.015	.....
16	2 kilos. sand, 100 gms. casein, 10 gms. sodium hydrogen phosphate	.36	6.46	.025	.....
17	2 kilos, soil, 80 gms. egg albumin, 10 gms. iron succinate	.79	9.49	.061	.155
18	2 kilos, soil, 70 gms. egg albumin, 5 gms. iron succinate, 3 gms. potassium carb. and 3 gms. sodium hydrogen phosphate	.76	8.23	.079	.127

COMBINATION OF HUMUS WITH THE POTASH OF SOILS

Vegetable and animal materials in their decay combine with the potash of the soil as well as with the phosphoric acid. In former investigations, cow manure, meat scraps and flour produced humus that united with some of the potash of the soil while the humus from sugar, saw dust and straw was not able to fix any of the soil potash. In this investigation, gliadin and

egg albumin which contained approximately .1 per cent each of potash produced a humus that combined with appreciable amounts of potash. The original soil yielded a humus containing .006 per cent humic potash. After the gliadin and egg albumin had undergone decay for one year in contact with soil, the humus showed a gain of 25 to 40 per cent of potash. In the case of commercial casein which contained .44 per cent of potash there was no addition of this element during humification. In three of the boxes, 6, 10 and 18, where potash salts in large amounts were added to casein and egg albumin, the final humus extract contained respectively .3, .44 and .59 grams of potash showing that the capacity of the humus to absorb potash, as in the case of the phosphoric acid, is limited. In box No. 9 where sodium, ammonium phosphate was added there was a loss of potash from the humus probably due to the excess of sodium causing a replacement of the potassium.

TABLE III. Combination of Humus with Soil Potash.

Box No..	Soil Used Gms.	Huus Forming ...Materials Gms.	Salts Added Gms	Humic Potash in Original Box. Gms	Humic Potash at Close Gms	Gain Gms
1	2000	Gliadin 75	.....	.19	.24	.05
2	2000	" 80	CaCO3 2	.20	.28	.08
3	2000	Egg Alb 80	.....	.20	.24	.04
5	2000	" 80	NaNH4HPO4. 4	.20	.29	.09
7	2000	Casein 80	.....	.44	.44	..
8	2000	" 80	CaCO3 2	.44	.50	.06
9	2000	" 80	NaNH4HPO4. 4	.44	.33	.11
17	2000	Egg Alb. 80	Iron succinate 10	.20	.32	.12

LOSSES OF NITROGEN DURING HUMIFICATION.

During the process of humification, there is a combination of phosphoric acid, potash and other minerals of the soil with the humus, followed by a loss of nitrogen. The loss of nitrogen from soils has been discussed in a number of former bulletins. In this investigation, losses of nitrogen during humus production were excessive—due undoubtedly to the fermentable nature of the materials used, and the favorable conditions for nitrification. The nitrogen content of the soils at the close of the experiment showed a loss of from 63 to 78 per cent of the original stock of nitrogen present in the materials used for producing the humus. Had a crop been grown this nitrogen would have been available largely for plant food purposes.

While these losses are much larger than actually occur in field operations, they show how it is possible for soils rich in nitrogen to readily lose this element by injudicious methods of cultivation, and for the loss of nitrogen through rapid decay of the humus during continuous grain cultivation without rotation or application of farm manures to amount to four and five times that removed by crops. The losses of nitrogen during humification are given in the following tables:

TABLE IV. Losses of Nitrogen During Humification.

Box No	CONTENTS	Nitrogen in Grams. At Beginning of Experiment	At Close of Experiment	Loss	Loss Per Cent.
1	2 kilos, subsoil 70 gms. gliadin..	11.284	4.074	7 210	63.8
2	2 kilos, subsoil. 80 gms, gliadin, calcium carb	11.966	4.200	7 706	64.9
3	2 kilos, subsoil, 80 gms. egg albumin	12.186	4.551	7.635	62.7
4	2 kilos, subsoil, 80 gms, egg albumin, calcium carb	12.186	3.203	8.983	73 7
5	2 kilos, subsoil, 80 gms, egg albumin, sodium phosphate ..	12.481	3.203	9.278	74.3
6	2 kilos, subsoil, 80 gms. casein, potass. sulfate	12.186	3.548	8 638	70.9
7	2 kilos, subsoil, 80 gms, casein	11.199	2.419	8.771	78.3
8	2 kilos, subsoil, 80 gms. casein, calcium carb	11.190	2.388	8.802	78.7
9	2 kilos, subsoil, 80 gms. casein, sodium phosphate	11.485	2.857	8.628	75.1
10	2 kilos, subsoil, 80 gms. casein, potass, sulfate	11.190	2.381	8.809	74.0
17	2 kilos, subsoil, 80 gms, egg albumin, iron salts	12.186	3.217	8.969	73.6
18	2 kilos, subsoil, 70 gms. egg albumin, iron salts, etc ..	10.796	2.628	8.168	75.7

FORM OF THE NITROGEN IN HUMUS.

Experiments were undertaken to determine the form in which nitrogen is present in productive soils particularly in the humus. Sestine (1) obtained only a small amount of amide nitrogen from peaty soils. Andre (2) found that by the action of lime for 82 days from 5 to 6 per cent of the nitrogen in peat and vegetable mould was obtained as ammonia and easily decomposed amides, while at higher temperatures from 10 to 12. per cent was obtained. The work of other investigators shows that the larger portion of the nitrogen in humus is in non amide forms.

(1) Lander, Ver. Stat. 1898, Bd. 51, 5, 153.
(2) Bul. Soc. Chim. Paris, 11-12, 1894, No. 15, pp. 771-781.

Four samples of fertile soil were tested for albuminoid nitrogen by Stutzer's method and nearly as much "albuminoid" as total nitrogen was obtained. While the insoluble nitrogen by Stutzer's method, conventionally termed albuminoid nitrogen, cannot be regarded as all being in albuminoid form, the results are valuable as indicating the presence of but little amid nitrogen in fertile soils. The soils were also digested for three hours with a dilute acid pepsin solution (2.2 parts pepsin and 15 parts acid per 1,000) and it was found that only a small part of the nitrogen was rendered soluble. The results are given in the following table:

TABLE V. Total Albuminoid and Pepsin Soluble Nitrogen in Soils.

Soil No.	Total Nitrogen Per Cent	Insoluble Nitrogen Per Cent	Pepsin Soluble Nitrogen Per Cent
202	.193	.193	.03
224	.291	.288	.03
277	.293	.293	.02.
Plot 2	.231	.218	.02

From 10 to 15 per cent of the total nitrogen was soluble in a dilute pepsin solution, indicating that the larger portion of the soil nitrogen is in such forms as not to yield to peptonizing action.

The results taken as a whole indicate that in an average fertile soil but little of the nitrogen which forms part of the humus is in amide condition, the larger portion being in forms allied to insoluble proteids and not readily acted upon by a dilute acid pepsin solution.

In the process of humification, an appreciable amount of the organic matter is rendered soluble and is obtained in the soil leachings. This was particularly noticeable in the case of the soils leached during the growing season to supply soluble plant food for the plants grown in prepared sand as described in the preceding article, "The Water Soluble Plant Food of Soils." The presence of these organic compounds in many natural waters is well known, some waters containing so much soluble organic matter as to be undesirable for household purposes. The soluble humus compounds are the products formed from the decay of the insoluble humus. The soluble humus products are

chemically combined with some mineral matter. The amount of water soluble humus in soils at any one time is small, that lost by leaching and in drainage water is replaced through decay of the insoluble humus which gradually decreases in amount unless fresh supplies of humus forming materials are added to the soil.

THE VALUE OF HUMUS AS PLANT FOOD AND AS A FACTOR IN SOIL FERTILITY.

The value of humates as plant food is discussed in former bulletins of this station where experiments are reported which show that oats, wheat and barley can be grown in prepared sand when the only mineral food is that combined with the humus. Later investigations by Nefedor (1) on the black soils of Russia show that grain crops when grown upon such soils obtain a large portion of their mineral food from that combined with the humus.

While the chemical composition of humus is not well understood, there are certain facts which are well known and are utilized by farmers in maintaining the fertility of the soil. Through the decay of farm manures and crop residues, resulting from crop rotations, larger yields are obtained, and soils are permanently benefited. During the decay of animal and vegetable matters, acid products are formed which unite with the mineral matter of the soil particularly with the potash and phosphoric acid forming compounds known as humates which are valuable forms of plant food. In the absence of sufficient basic matter in the soil, the acid remains unneutralized and the soil unproductive, but by the addition of lime, wood ashes and other alkaline substances, this free acid is neutralized and the process of humus production allowed to continue. Excessive decay of the humus favored by injudicious methods of cultivation causes an excessive loss of nitrogen from the soil and a loss of plant food in humate forms. This often results in a decline in yield of farm crops. A moderate rate of decay of humus in a soil is desirable so as to render both the nitrogen and the mineral plant food available. The humus lost through decay shoulld be replaced by farm manures, and sod crop residues the result of crop rotations, while the stock of soil nitrogen should be replenished by the cultivation of clover and other legumes.

(1) Abstract, Expt. Station Record, Vol. X, No. 4.

INTRODUCTION.

This bulletin contains five articles relating to the composition and value of grains. The first, "Heavy and Light Weight Grains" discusses the composition and characteristics of heavy and light weight wheat, oats and barley, and it is shown that while the light weight grains have the larger percentage amount, the heavy weight grains have the larger amount, of protein, phosphoric acid and potash, and that the additional plant food in the heavy weight grains associated with a more mature germ gives the matured heavy weight kernels decidedly the advantage for seed purposes.

The second article "Starchy and Glutenous Grains" is a continuation of the work on starchy and glutenous wheats reported in Bulletin No. 85 of this station. It is shown that while there is a general uniformity in the composition of wheat grown from a uniform lot of seed, it is possbile to select distinct types of starchy and glutenous kernels showing a difference of from one to three per cent of protein in favor of the glutenous kernels. The physical characteristics of the two types of wheat are sufficiently pronounced to allow the separation into starchy and glutenous wheats to be readily made. It is also shown that different heads grown from the same seed and also different kernels produced on the same head will show various degrees of starchy and glutenous character; each head and kernel as far as chemical composition is concerned has an individuality. It was also found that starchy and glutenous types of rye and oats could be distinguished the same as in the case of wheat.

The third article treats of light and dark colored flax seeds, and it was found that as far as oil content, general chemical composition, germinating powers and composition of the oil are concerned, there was no appreciable difference between light and dark brown flax seeds.

Rusted wheat is discussed in the fourth article. The rust affected the plant after the protein had been produced in the leaves and before it was transferred to the seeds, resulting in the wheat straw containing a high percentage of protein and the grain being small, shriveled and dull in appearance.

The fifth article treats of the milling tests of wheat. It discusses the methods employed to determine the milling and the bread making value of wheats and gives a comparative test of the different grades of wheat as found on the market. The flour yield and the composition and bread making value of rusted wheat are also discussed.

HEAVY AND LIGHT WEIGHT GRAINS.

HARRY SNYDER.

Since the commercial quality of grain is determined largely by soundness and weight per bushel, it has been deemed advisable to make an investigation to ascertain the differences in chemical composition and physical properties between light and heavy weight grains. For purposes of this investigation samples of heavy and light weight wheat, oats and barley were obtained by hand picking. These samples were then submitted to chemical analysis.

Much care was taken in the selection of the samples. Medium sized, plump, heavy weight and well filled kernels were selected and also from the same lot of grain another sample of medium sized imperfectly filled and light weight kernels. Other characteristics as color and soundness were kept as nearly alike as possible in each of the two types of seed. Some of the grains were obtained from the Minnesota State Grain and Warehouse Commission, and others from the Agricultural Division of the Experiment Station, from samples that were under investigation for purposes of improvement.

Numerous analyses have been made of heavy and light weight seeds but no extended investigations appear to have been made of the commercial yield of products from such grains or of the amount of reserve plant food which they contain and are capable of supplying to growing crops. It has been shown by Hellreigel and others that heavy weight seed wheat always produces a better stand of grain and more vigorous plants than light weight seed. In the case of soils of high fertility, the difference in yield from heavy and light weight seed was not as pronounced as in the case of soils of low and medium fertility when the heavy weight seed wheat produced by far the largest yield per acre. The difference in the appearance of the crops grown from heavy and light weight seed was noticeable during the entire period of growth and was in favor of the heavy weight seed. It is quite evident that for seed purposes, sound, heavy weight kernels have decided advantages over immature light weight seed.

The difference in weight of seeds is often quite large, one hundred kernels of wheat may weight 1 1-2 grains and from the same sample, it is possible to select 100 kernels weighing 6

grams. As great differences in weight are found in other grains.

In this investigation the terms heavy and light weight seeds refer to those of the same variety or from the same source, the heavy weight seeds being sound, well filled, with a high weight per bushel and others inperfectly filled, with a low weight per bushel.

In the discussion of results, first the percentage composition is considered, that is, the amounts of nutrients and various compounds present in 100 pounds of the grain without regard to the size of the kernels, and then the total weight or amount of nutrients in a given number of seeds. As far as composition is concerned, chemical analysis does not show such a great difference in the per cent of nutrients in light and heavy weight seeds. The light weight seeds have a tendency to contain a larger percentage of nitrogen, phosphoric acid and potash than the heavy weight seeds. This would naturally suggest that such seeds are the most valuable for commercial and seed purposes, but a careful interpretation of the results when the weight of the seeds is considered jointly with the percentage composition leads to just the opposite conclusion namely: that the heavy weight seeds are decidedly preferable for both seed and commercial purposes.

While there is a somewhat larger percentage of nitrogen, phosphoric acid and potash in light weight seeds, it is found that when the weight per 100 kernels is multiplied by the percentage composition, 100 heavy weight seeds contain from two to four times as much nitrogen, phosphoric acid and potash as the light weight seeds. Thus while the light weight immature seeds have somewhat the advantage in percentage composition the heavy weight seeds have decidedly the advantage because of their greater weight, and contain a much larger total although a smaller percentage amount of the nutrients than the light weight seeds.

In a former bulletin, No. 85, of this station, it was shown that light weight wheat contains a higher percentage of nitrogen than heavy weight wheat. In this investigation, it has been found that the general tendency for the light weight seeds to contain a higher percentage of nitrogen as well as phosphoric acid and potash is also common to barley, oats and rye.

In one sample of barley there was a difference of only .17 per cent in the protein content in favor of the light weight seeds while in another sample, the difference amounted to 3.87 per cent.

In former investigations, it was observed that wheat,[1] clover,[2] alfalfa[3] and flax,[4] in the early stages of growth assimilate their nitrogen, phosphoric acid and potash with great avidity. By the time a crop has produced one-half of its organic matter from 70 to 80 per cent of the nitrogen and mineral matter have been assimilated, thus making the plants in the early stages of growth contain a larger percentage but a much smaller total amount of these building materials. It has been observed that the light weight seeds contain a larger percentage amount of the elements and compounds named because they have failed to reach as high a degree of maturity as the heavy weight kernels and that with the filling out of the kernel, there is an increase in the weight of the seed but not a proportional increase in the per centages of nitrogen, phosphoric acid and potash.

From the results of this investigation, it is quite evident that when seeds are taken from the same source, a light weight per bushel is nearly always accompanied by a high percentage of nitrogen, phosphoric acid and potash and this is indicative of a lower degree of maturity than in the case of heavy weight grains where there is a smaller percentage amount but a larger total amount of these materials. It is not possible to judge the degree of maturity of grains taken from different sources by the percentage amounts of nutrients present but when grains of the same variety and from the same source were compared it was found that a high weight per bushel and full maturity were associated with comparatively low percentages of nitrogen, phosphoric acid and potash.

The different amounts of commercial products, as the various grades of flour, obtained from heavy and light weight wheat seeds were quite noticeable. This is discussed more in detail in another article of this bulletin. The heavier weight wheat produced a proportionally larger amount of the commercial grades of flour than the light weight wheat. No investigations appear to have been made to determine the relationship between the weight per bushel and yield of commercial products from other cereals.

From the results of this investigation, it is quite evident that it is not possibl to determine the commercial value of a cereal either for food or seed purposes on the basis of nitrogen content alone because in selecting grains of the highest nitrogen content without regard to any other factor, it is

(1) Minn. Ex. Sta. Bul. No. 29
(2) Minn. Ex. Sta. Bul. No. 34.
(3) Minn. Ex. Sta. Bul. No. 80.
(4) Minn. Ex. Sta. Bul. No. 47.

possible to select the light weight and less mature grains rather than the heavy weight, the most valuable and mature ones. Whenever high nitrogen content is associated with heavy weight, soundness and other desirable characteristics, it is most advantageous, but the nitrogen, phosphoric acid or potash content alone without regard to weight per bushel or other desirable characteristics cannot be taken as an indication of the value of a cereal. In 100 kernels of heavy weight barley there was found to be about one-third more phosphoric acid, nearly a half more nitrogen and about 10 per cent more potash than in 100 light weight kernels. It is quite evident that when all other factors are equal the heavy weight seed has the advantage by containing a large amount of reserve plant food for starting the growth of the crop.

In three separate samples of oats 100 heavy weight kernels were found to contain about 1.8 times as much phosphoric acid, 1.5 times as much potash and nearly twice as much nitrogen as 100 light weight seeds. In 100 heavy weight kernels about the same total amount of phosphoric acid and potash and twice as much nitrogen were found as in 100 light weight seeds.

The amount of nitrogen, phosphoric acid and potash is in no way a measure of the germinating power, but the plants from heavy weight seeds have more vitality and invariably reach a higher degree of maturity. In fully matured heavy weight seed, the conditions are more favorable also for securing a germ of high vitality and good germinating powers. It is quite apparent that all other factors being equal, the heavy weight grains supply the young plants with a much larger amount of reserve food than light weight seeds. The additional plant food in heavy weight grains is an important factor in promoting growth.

When heavy weight grains are selected for seed purposes, the additional reserve plant food at the disposal of the growing crop is often sufficient to materially affect the vigor of growth and the yield of grain. On the basis of the additional plant food alone, the farmer is repaid for using heavy weight seed. The maximum yield of grain is secured when good seed is used and the fertility of the soil is kept up by the use of farm manures and the rotation of crops. Fertility and crop rotations are discussed in bulletin No. 89 of this station.

Valuable assistance has been given in the investigation by Mr. Robert Dewar in connection with the milling and baking tets, and by Mr. Hummel, assistant chemist, Mr. Hoagland, Miss Parker and Miss Craig, laboratory assistants, in carrying on various features of the analytical work.

In table No.6 is given the percentage composition of heavy and light weight seeds and in table No. 7, the total amount in grams of nitrogen, phosphoric acid and potash per 100 kernels of each kind of seed. In table No. 6 it will be observed that the light weight seeds contain the larger percentage amounts of the elements and compounds mentioned, while table No. 7 shows that 100 kernels of the heavy weight seeds contain a much larger total amount of all these elements.

TABLE VI. Composition of Heavy and Light Weight Seeds.

No.	SAMPLES.	Weight per 100 Kernels	Crude Protein (Nx6.25)	Phosphoric Acid.	Potash.
		Grams.	Per cent.	Per cent.	Per cent.
	Barley—				
1	Heavy weight	3.999	11 07	2.03	.373
2	Light "	1.947	10.90	2 71	.969
3	Heavy "	3.799	8.94	2.08	.741
4	Light "	2.109	12.81	2.97	.969
	Oats—				
5	Heavy weight	3.579	8.17	1.65	665
6	Light "	1.594	8 69	1.75	.894
7	Heavy "	3.344	11.34	1.66	.675
8	Light "	1.591	11.66	2 05	.89
9	Heavy "	3.376	14.85	1.66	.665
10	Light "	1.695	17.72	2.24	.907
	Wheat—				
11	Heavy weight	2.753	16.72	1.41	.519
12	Light "	1.325	17.97	3.01	1 057

TABLE VII. Total Nutrients in Heavy and Light Weight Seeds.

No	SAMPLES	Phosphoric Acid 100 Kernels.	Potash 100 Kernels.	Protein (Nx6.25) 100 Kernels.
		Grams.	Grams.	Grams.
	Barley—			
1	Heavy Weight	.081	.015	.361
2	Light "	.053	.019	.212
3	Heavy "	.079	.028	.340
4	Light "	.063	.020	.270
	Oats—			
5	Heavy Weight	.059	.024	.292
6	Light "	.028	.014	.139
7	Heavy "	.055	.023	.379
8	Light "	.033	.014	.186
9	Heavy "	.056	.023	.501
10	Light "	.034	.015	.300
	Wheat—			
11	Heavy Weight	.039	.014	.460
12	Light "	.040	.014	.238

GLUTENOUS AND STARCHY GRAINS.

HARRY SNYDER.

WHEAT.

In a former bulletin, No. 85, of this station, the physical characteristics associated with glutenous and starchy wheats are discussed. It was found that when a sample of wheat from the same seed or source was examined, differences in size, color and general appearance of the kernels were discernible. In the case of about 85 samples, two types of kernels one starchy and one glutenous were selected from each.

The glutenous wheat kernels are characterized by a darker, amber color, and a harder more flinty texture than the starchy kernels. When the two types of kernels are cut through horizontally, the amber color and the hard and horny character of the glutenous wheats and the lighter color and more floury nature of the softer starchy wheats are readily observed. The difference in protein content of glutenous and starchy kernels from the same seed or source was found to range from 1.6 to 4.87 per cent in favor of the glutenous kernels.

Since the publication of bulletin No. 85, some additional tests have been made as to the protein content of starchy and glutenous wheats raised from the same seed. The results are as follows:

Source of Seed.	Glutenous Wheat Protein. Per cent.	Starchy Wheat Protein Per cent.
Chace Anderson, Hutchinson, Minn	16.85	13.71
P. M. Johnson, Pennock, N. D.	14.20	15.53
I. Emerson, W. Concord, Minn	17.76	16.25
G. A. Daniels, Randall, Minn	14.64	11.69
T. A. Hoverstad, Crookston, Minn	14.96	12.21
Experiment Station	14.00	11.08
Experiment Station	13.75	11.60
Experiment Station	14.66	11.57
Experiment Station	13.07	11.03
Experiment Station	14.15	12.71
Experiment Station	16.59	15.11
Experiment Station	14.34	11.81

These results are so similar to those presented in Bulletin No. 85, that no farther discussion of them is necessary.

In a few cases anomolous wheat kernels were found in which one-half was starchy while the other half was glutenous.

In order to determine the influence of the germ upon the nitrogen content of wheat, a number of nitrogen determinations were made of the kernels with and without the germ, the germ end being removed with a sharp knife. A number of determinations were also made of the germ end and of what may be called the starchy end of the kernel. The results are given in the following tables:

Sample No.		Normal Seeds	Seeds with Germ Ends Removed
12.	Protein, per cent	10.02	9.49
83.	Protein, per cent	15.17	14.14
26.	Protein, per cent	8.70	8.16
31.	Protein, per cent	14.40	14.23
	Average	12.07	11.50

		Protein Per Cent. Germ End of Kernel	Starchy End of Kernel
26.	Strachy wheat	8.87	7.13
	Glutenous wheat	11.18	9.02
31.	Strachy wheat	15.31	12.64
	Glutenous wheat	16.23	14.16
83.	Starchy wheat	14.08	13.12
	Glutenous wheat	17.16	15.54
12.	Starchy wheat	10.47	8.32
	Glutenous wheat	12.71	10.58
83.	Starchy wheat	13.78	13.66
	Glutenous wheat	16.35	16.05
31.	Starchy wheat	13.70	13.34
	Glutenous wheat	15.12	14.93
	Average	13.75	12.37

It was not possible by means of a knife to perfectly separate the germ, and hence comparisons as to the influence of the germ upon the protein content of the kernel can be made only in a general way. When the germ was removed the samples tested contained .56 per cent less protein than the entire kernels and the "starchy end" of the wheat kernel was found to contain 1.38 per cent less protein than the germ end.

In the study of separate wheat heads, slight differences in the nitrogen content of individual kernels were observed. In many cases, it was possible to distinguish starchy and glutenous seed in the same wheat head. When grown from the

same glutenous seed, individual kernels varying in degree of glutenous character were discernable. Four samples of wheat heads grown from a uniform lot of seed containing an average of 14.57 per cent of protein on a dry matter basis contained from 13.81 to 18.45 per cent of protein, as will be observed in the following table:

TABLE VIII. Protein Content of Glutenous Wheat.

	Head 1.	Head 2.	Head 3.
Lot 1	17.51	18.45	16.43
Lot 2	16.05	15.43	13.81
Lot 3	15.80	15.93	15.45
Lot 4	16.93	16.19	16.28

(The above results are on the basis of dry matter).

When three heads of each kind were selected and a separation of the seeds into high and low gluten lots was made, it was found in some cases that half of the kernels were more and half were less glutenous in character. Some of the wheat heads contained kernels so uniform in appearance that no distinction could be made.

TABLE IX. Protein Content of Glutenous and Starchy Kernels Produced upon the Same Wheat Head.

	Heads Nos.	Glutenous Kernels. Per cent.	Starchy Kernels. Per cent.
Lot 1	4, 5, 6	15.56	17.84
Lot 2	7, 8, 9	16.71	15.83
Lot 3	10, 11, 12	17.43	15.86
Lot 4	13, 14, 15	17.26	15.64

While the differences in protein content of wheat from individual heads grown from similar seed are small, and there is a general uniformity as to high or low protein content there is still an appreciable difference showing that each head and each kernel as far as chemical composition is concerned has an individuality.

CORN.

Investigations by Hopkins at the Illinois Station have shown that in the case of corn there are definite physical properties associated with glutenous and starchy kernels which are sufficiently pronounced to enable one to readily distinguish the

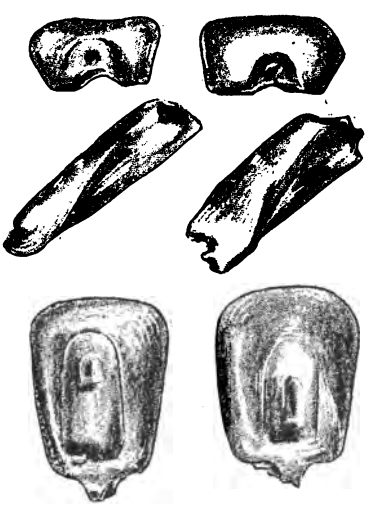
two types of corn. In order to determine the extent to which differences in the protein content occur in average samples of corn grown under Minnesota conditions, the following analyses were made:

Sample No.	Protein Content of Corn. Starchy. Per cent.	Glutenous. Per cent.
1	10.01	11.39
2	9.07	9.55
3	10.29	11.23
4	10.36	10.91
5	8.86	10.00
6	11.26	12.00
7	8.89	10.26
8	9.21	9.10
9		8.92
		8.89
Average	9.74	10.56

From each lot of corn, samples of starchy and glutenous kernels were selected by hand picking. In the case of sample No. 9, the kernels were so uniform that it was not possible to select with any degree of satisfaction the two types of seeds, hence the analyses were accredited as either starchy or glutenous. In the case of No. 8, the sample selected as the starchy type contained slightly more protein than the one selected as the glutenous type. In all other cases the starchy kernels contained from about .5 to nearly 1.50 per cent less protein than the glutenous kernels. In most cases the glutenous kernels were of a darker hue than the starchy kernels, but this holds good only in a general way with kernels grown from the same lot of seed, and is not applicable when comparisons are made between corn samples from different sources or from different lots of seed. White corn for example may contain as much or even more protein than yellow corn grown under the same conditions of climate and soil. Three samples each of yellow and white corn grown under similar conditions but from different kinds of seed were found to contain the following amounts of protein:

Sample No.	Yellow Corn. Per cent Protein.	White Corn. Per cent Protein.
1	12.05	11.04
2	10.86	10.86
3	10.10	11.23

The description with illustration of the glutenous and starchy types of corn as given by Hopkins of the Illinois Station is as follows: "By making cross sections and longitu linal sections of several kernels from an ear of corn, one can judge, with a very satisfactory degree of accuracy, whether the corn is rich or poor in protein. The illustration here shown was made from a photograph taken of corn kernels and sections with a magnification of three diameters. At the left are two sections and a whole kernel from corn containing 14.92 per cent of protein. The sections and kernel at the right are from corn containing 7.76 per cent of protein. About one-fourth of the kernel was cut off from the tip end in making the cross sections. In the longitudinal sections the tip end of the kernel points upward to the right. It will be seen that in the cross sections the white starchy layer nearly disappears in the high-protein corn, but becomes very prominent in the low-protein corn. In the longitudinal sections this difference is also apparent, the white starch in the high-protein corn being confined almost entirely to the crown end of the kernel, while the low-protein corn it extends into the tip end in considerable amount. The germ in the high-protein corn is somewhat larger. This is also indicated by the depressions in the whole kernels."



Corn with 14.92 per Cent. Protein. Corn with 7.76 per Cent. Protein

FIG. 182.—Starchy and Glutinous Corn, after Hopkins. (From Illinois Experiment Station Bulletin.)

RYE.

When it was found that glutenous types of both wheat and corn are associated with definite physical characteristics and can be distinguished, it was deemed advisable to include rye in the investigation. A few samples were obtained from the State Grain and Warehouse Commission and it was found that light and dark colored seeds corresponding to hard glutenous and softer starchy kernels could readily be distinguished as in the case of wheat and corn. The results obtained with rye are as follows:

Sample No.		Starchy Rye.	Glutenous Rye.
1.	Protein, per cent	9.11	10.59
2.	Protein, per cent	11.94	12.16
3.	Protein, per cent	9.58	10.02
4.	Protein, per cent	10.00	10.85
	Average	10.16	10.91

In working with rye occasionally kernels of a greenish tinge are observed, due to lack of complete maturity; such kernels usually have a high protein content as noted in the preceding article on light weight and immature grain. In the samples tested, greenish kernels were found which contained 10.67, 13.12, 11.56 and 10.07 per cent respectively of protein. Owing to the difficulty in obtaining a large variety of samples, the investigation with starchy and glutenous rye was not carried as far as in the case of wheat. The results however, show from .5 to 1.50 per cent more protein in the darker colored and more flinty rye kernels than in the lighter colored and more starchy ones, indicating that with rye as in the case of wheat and corn there are glutenous and starchy types.

OATS.

Four samples of oats representing the different commercial grades as found on the market were obtained from the Minnesota Railroad and Warehouse Commission. On account of the presence of the hull, it is more difficult to study the individuality of the oat kernel than is the case with wheat, corn and rye. However, in all of the samples three distinct types of kernels could be distinguished, those of light and those of dark amber color, and also kernels of a greenish tinge.

	Protein Content of Oats.		
	Light colored starchy type.	Dark colored glutenous type.	Greenish.
	Per cent.	Per cent.	Per cent.
No. 1	11.20	11.37	12.30
No. 2	11.11	11.69	12.15
No. 3	11.82	12.63	14.68
No. 4	10.98	11.39	13.56

Other samples of starchy and glutenous kernels were selected from numbers 1 and 4 by another analyst and found to contain respectively 10.35, 11.67, 10.96 and 11.28 per cent of protein.

The terms light colored and dark colored are used in only a comparative way. It is not intended to convey the idea that of two samples of oats, the lighter contain the least and the darker the most protein, but when light and dark kernels were selected from the same lot which had been grown from similar seed, the darker amber colored and flinty oats contained the larger content of protein, and the greenish tinged kernels contained more than either. Whether this would hold true in the case of a large number of samples remains to be investigated but as far as the work has been carried, it has been found that there are starchy and glutenous types of oats the same as starchy and glutenous types of wheat, corn and rye.

LIGHT AND DARK COLORED FLAXSEEDS.

HARRY SNYDER.

This investigation was undertaken at the request of Mr. A. C. Aaby of the State Board of Grain Appeals to determine the difference in the oil content of dark and light colored flax seeds. In many samples of sound and fully matured flax, light brown and dark brown seeds are distinguishable. In size, weight and other physical characteristics, the seeds are alike except in color, and it was desired to learn whether there was any difference in the oil content or in the chemical composition of the oil from the two types of seed.

In the grading of flax seed, weight per bushel, soundness and uniformity of seeds are the main factors which establish the grade. The presence of more than 12 1-2 per cent of "field, stack, storage or other damaged seeds" is sufficient to cause a sample of "mature, sound, dry and sweet flax seed" northern grown and weighing 51 pounds or more per bushel to be classed lower than No. 1 northern grade. Are the mediumly dark brown flax seeds damaged seeds or are they simply a type of mature sound seed? Upon this point, the commercial grade of the flaxseed sample is often dependent. In order to secure an answer to this question, samples of hand picked seed were submitted to chemical analysis, and the following result obtained:

No.		Per cent Oil in seeds	Per cent Crude protein	Per cent Ash
1.	Yellow tinged flaxseed	34.64	22.93	3.58
2.	Dark brown flaxseed	36.09	22.33	3.34
3.	Experiment Station flax	36.40	23.12	3.52
4.	Light brown flax seed	35.10	22.78	3.87

The dark brown flax seeds examined contained about one per cent more oil than the light brown seeds. This is not a large difference when it is recalled that the oil content in flax seed may range from 34 to 39 per cent. Both the light and dark brown flax seeds contained the average amount of oil with a slight difference in favor of the dark brown seeds. No appreciable difference was found in the protein content of the flax seeds examined.

A test was also made to determine the germinating power of the three types of flax seed as represented by samples Nos. 1, 2 and 4. It was believed that in case the dark brown seeds had been injured in any way in the field, stack or storage, it would show itself in lessened vitality of the seed. The results of the germination test are as follows:

Samples.	Total number seeds tested.	Number seeds germinated.
1. Yellow tinged flax seed	24	23 (1 weak plantlet)
2. Dark brown flax seed	24	24
4. Light brown	24	24

No difference was observed in the germinating powers of the dark and light brown flax seeds, indicating that as far as power to germinate is concerned both types are equally sound.

The oils extracted from the three types of seed were subjected to the iodine absorption test. They were dried over sulphuric acid to prevent oxidation and yielded the following results:

Sample.	Iodine. Absorption No.
1. Yellow flax seed	167
2. Dark brown flax seed	173.3
4. Light brown flax seed	167.4

It will be seen that there is no large difference between the iodine absorption numbers of the three samples. None of the samples gave either abnormally high or low iodine absorption numbers. In commercial testing of linseed oils preference is usually given to those of medium and high rather than those of a low absorption number.

As far as oil content, general chemical composition, germinating powers, and properties of the oils as determined by the iodine absorption numbers are concerned, no appreciable difference was observed between light brown and dark brown flax seeds.

RUSTED WHEAT.

HARRY SNYDER.

The presence of black rust in some portions of this state has caused inquiries to be made as to the effects of rust upon the composition and feeding value of the straw and grain. In many instances the rust did not affect the crop until within a week or ten days of maturity, but then the rapidity with which the plants were affected was sufficient to materially influence the yield of the crop. Early seeded wheat on well drained land where the fertility of the soil had been kept up was much less affected by rust than late seeding on low or worn soil.

In a former publication, Bulletin No. 29, of this station, the composition of the wheat plant at different stages of development is given. In the case of rusted wheat, the plant was killed by the fungus disease before reaching maturity, hence we find the rusted crop having the same general composition as unripe wheat. The grain from rusted wheat is small in size, shrunken, and light in weight. The kernels have a dull appearance.

Six samples of wheat varying from very badly rusted to rust free, Nos. 1 to 6, were selected for purposes of investigation. Another sample No. 7 from the southwestern part of the state, a typical sample of grain producing a large yield of straw but failing to fill well was added to the list. From the analysis, it will be observed that the straw of the rusted grain contained a large amount of protein. Samples Nos. 1 and 2, which were the most seriously affected by the rust contained 6 23 and 6.94 per cent respectively of protein while sample No. 6 which was practically free from rust contained only 3.77 per cent.

It is evident that the wheat plant had assimilated from the soil all of the nitrogen necessary to produce a good yield of grain, but that the protein formed in the straw from the nitrogen and other elements in the leaves was prevented by the rust from being stored up in the seeds. Nearly all of the glutenous material which would have gone to form a larger number of kernels and more plump and matured ones was retained in the

straw. The intensity of the rust is almost proportional to the excess of protein remaining in the straw. The rusted wheat straw has nearly twice as much protein as normal ripe straw, and as much as is present in prairie and timothy hay, and it is this high protein content which imparts to the rusted wheat straw a high feeding value. It seems to be preferred by most farm animals to bright normal straw, and when farm stock is well cared for and fed grain and some other roughage as prairie hay or corn fodder then there appears to be no evil effect from the moderate feeding of the straw from rusted wheat. Any food stuff affected with a fungus disease must be fed with care, as some forms of fungi develop poisonous materials as alkaloidal bodies, but in the case of wheat rust, horses and cattle seem to have eaten the straw with impunity.

TABLE X. Composition of Wheat Straw Samples.

	Water	Ash	Protein	Fat	Carbo-hydrates	Crude Fiber
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1. Very rusty sample	9.81	8.05	6.23	.98	27.74	47.19
2. Very rusty sample	7.74	6.03	6.94	.51	30.08	48.70
3. Rusty sample, not serious	8.46	6.73	5.06	.96	31.48	47.31
4. Rusty sample, very light .	9.22	6.44	4.38	.97	32.86	46.13
5. Slightly rusted	7.67	6.42	4.58	.....	40.35	40.98
6. Rust free	8.32	6.78	3.77	1.16	42.29	37.68
7. Grain not well filled	7.22	6.68	6.19	1.05	36.15	42.71

In the case of the wheat which produced a rank growth of straw but a light yield of grain the large amount of protein in the straw would indicate an unbalanced condition of plant food, an excess of nitrogen and a deficiency of either phosphoric acid or potash. The straw upon analysis was found to contain .205 per cent of phosphoric acid and 1.79 per cent of potash while straw from grain grown on the Experiment Station farm and which yielded over 30 bushels per acre of wheat contained .35 per cent of phosphoric acid and 1.97 per cent of potash. Since the straw of the light yielding but rank growing grain crop contained an abnormal amount of nitrogen and a scant amount of phosphoric acid compared with the straw of a large yielding grain crop, it would suggest that there was a lack of available phosphoric acid in the soil. It is at least sufficiently suggestive to warrant the trial of a phosphate fertilizer in order to induce a more balanced crop growth. Frequently it is a lack of nitrogen which causes light yields of grain crops and not a lack of phosphoric acid.

The rusted wheat straws examined all contained a high percentage of phosphoric acid, and had full maturity resulted much of this phosphoric acid would have been stored up in the seed.

The effect of the rust upon the composition of the grain was most noticeable. The small, light weight, shrunken grains have much the same general composition as the light weight immature grains described in the first article of this bulletin. The rusted wheat kernels contained a higher percentage of protein, fibre and ash than sound, fully matured grain. When selected from the same field where they had been grown under uniform conditions and from the same seed, rusted and rust free grain had the following composition:

	Wheat from rusty plants	Wheat from rust free plants
	Pr. Ct.	Pr. Ct.
Ash	2.87	1.92
Crude protein	16.37	13.34
Ether extract	2.41	2.24
Crude fibre	3.67	2.01
Carbohydrates	62.50	70.73
Moisture	12.18	9.76

Some of the rusted wheat samples contained as high as 19.30 per cent of protein. At the time this investigation was in progress an advanced copy of a report upon the same subject was received from Mr. Frank T. Shutt, Chemist of the Dominion Experimental Farms at Ottawa, Canada. Since the general results are so similar to those presented in this article, it was not deemed necessary to carry this investigation farther for purposes of verfication.

The flour yield of rusted wheat and the quality of the flour were also investigated. These results can be more advantageously presented in the next article.

Uncleaned, rusted wheat should not be used for seed purposes, because of the unevenness of the kernels, the lack of vitality in the light weight immature seeds, and the lack of reserve plant food which, in case the soil is not in the highest state of fertility, will affect the vigor of growth and the ultimate yield of the crop. Rusted wheat is practically light weight wheat. Bacteriologists claim that the black rust of wheat is not transmitted by the use of rusted seed. Being a light weight seed, the statements made in the first article of

this bulletin "Heavy and Light Weight Grains" would apply to light weight rusted wheat. In nearly all samples of rusted wheat, there are some reasonably heavy well filled kernels suitable for seed purposes. When the light weight and immature grains are removed by screening and the use of a fanning mill, the quality of the seed is greatly improved. This should be done in all cases where rusted seed is used so as to secure the benefits as pointed out in the first article from the use of heavier weight and more mature kernels. At the Nebraska Experiment Station a difference of 6.5 bushels per acre in favor of heavy weight seed over light weight seed was secured in 1902. At other stations, the use of heavy weight seed has given an increase of from one to three bushels over light weight seed. From the experiments made by the American experiment stations, it has been found that the use of heavy weight seed results in an average increase of about three bushels per acre which is more than enough to pay for cleaning th seed wheat, or even purchasing a better grade of wheat.

MILLING TESTS OF WHEAT.

HARRY SNYDER.

In order to more thoroughly test the value of wheats for milling, breadmaking and nutritive purposes, an experimental roller mill was designed and installed in the chemical laboratory in 1903. A small stand of corrugated and smooth rolls and a sifter had previously been used but was not found suitable for obtaining the flour yield of a sample of wheat with any degree of accuracy; for while this small outfit gave a fair quality of straight grade flour, it was not possible to obtain with it the usual grade of flour and offals as secured by the patent roller process of milling. So it was found necessary to design and install a complete miniature roller milling system. The prelimnary plans were made by Mr. M. A. Gray, a practical miller, and at the time a special student in the College of Agriculture. The preliminary plans were revised and the machinery made by the Allis-Chalmers Company of Milwaukee, Wis.

The milling system consists of two stands of corrugated rolls and two sets of smooth rolls for the reduction of the middlings, a Reliance plain sifter containing thirty separate sieves and bolting cloths, and an aspirator for purifyng the middlings. The rolls and aspirator are all connected by elevators. Power is supplied for running the machinery from a 15-horse power electric motor, the current being obtained from the central power station of the institution. Eight-horse power is required for operating the mill and it takes about an hour to mill a bushel of wheat. Two middlings, or patent grades and a break flour are obtained and also a "tailings" flour and the offals; bran, shorts and tailings. From 68 to 72 per cent of flour can be produced depending upon the character of the wheat milled. While this system does not mill quite as exhaustively as a longer break system, it does very satisfactory work and enables comparative results to be secured.

This experimental mill has been found of great assistance in the study of wheat and flour problems, particularly in the testing of new varieties of wheat and in the preparation of standard grades of flour for nutrition investigations. The general arrangement of the machinery and the construction of the shifter can be observed in the illustrations, figures 185 and 186.

The operating of the mill has always been in the hands of experienced millers. The institution has been fortunate in having among its students young men who have served an apprenticeship in milling before coming to the College of Agriculture to take up work in wheat and flour testing. The operating of an experimental flour mill should not be undertaken by a novice any more than the manufacture of butter or cheese.

The farmer is interested in securing varieties of wheat which give good yields per acre and command a good market price. The miller desires wheat which will make a high grade marketable quality of flour, one of good keeping qualities and one which gives good yields and does not require excessive power for grinding. The baker desires what are technically called strong flours, which make a large number of loaves per barrel, and produce a large loaf of bread of good physical properties and one that does not dry out readily.

It is possible to secure wheats which possess in some degree all of these characteristics and it is believed that such wheats will prove the most desirable ones for the farmer to produce.

Without the experimental mill the study of the various problems in connection with wheat and flour, particularly from the agricultural point of view, would not have been possible. In order to make this work more complete, apparatus and appliances have been devised and installed for carrying on investigations in bread making and for other technical tests of flour. In some of the experiments the nutritive value of the flour and bread have been determined by digestion trials with men, and thus the milling, baking and nutrition investigatons have been carried on with one lot of wheat and under conditions subject to experimental control. It is believed that ultimately better results will be secured from such a study of wheat than from isolated experiments with separate and disconnected parts of the problem.

In order to test the comparative quality of the standard grades of wheat of the 1904 crop, ten samples representing the various grades were obtained from an elevator and submitted to milling and baking tests.

DESCRIPTION OF SAMPLES.

Sample.

No. 1. Grade, No. 1 Northern as taken into the elevator; clean, bright wheat, some light and some dark colored kernels, no shrunken kernels, weight 61 lbs. per bushel when cleaned. A good sample of No. 1 Northern wheat.

No. 2. Grade, No. 1 Northern as inspected out of an elevator, a fair sample for grade, but not as bright as sample No. 1, some oat seeds present and a few shrunken kernels, weight 60 lbs. per bushel when cleaned.

No. 3. Grade, No. 2 Northern. A fair sample of this grade of wheat, some small kernels, cockle and a few immature seeds present, weight 58 lbs. per bushel when cleaned.

No. 4. Grade, No. 3 Northern weighing 53 lbs. per bushel when cleaned. A fair sample of this grade of wheat. It contained more shrunken and immature kernels than sample No. 3.

No. 5. Grade No. 4 Northern weighing 52 lbs. per bushel when clean. It resembled sample No. 4, but was not so bright in color. It contained immature and shrunken kernels.

No. 6. Rejected Wheat. This sample weighed when cleaned 49½ lbs. per bushel, it was a typical sample of rusted wheat. The seeds were shrunken and dead in appearance and a considerable number of discolored seeds were present.

No. 7. No grade. Sample somewhat moist weight 56 lbs. per bushel cleaned. Many dull and discolored seeds present, also some barley seeds.

No. 8. Grade, No. 2 Northern. Similar to sample No. 3. Weight per bushel 58 lbs. when cleaned.

No. 9. Grade, No. 3 Northern. Similar to sample No. 4. Weight 55 lbs. per bushel when cleaned.

No. 10. Grade, No. 4 Northern. Similar to sample No. 5. Weight 51 lbs. per bushel when cleaned.

TABLE XI. Milling Tests of Wheat.

Sample No.		Per Cent. of Total Flour Recovered	Per Cent. of Patent Flour Obtained.	Per Cent. of Bran.
1.	No. 1 Northern, inspected in	68.5	46.6	20.0
2.	No. 1 Northern, inspected ou	64.4	45.0	22.0
3.	No. 2 Northern	60.9	42.2	27.7
4.	No. 3 Northern	57.6	43.4	27.0
5.	No. 4 Northern	58.7	41.2	26.0
6.	Rejected Wheat	51.7	40.0	29.5
7.	No grade	54.8	42.2	28.9
8.	No. 2 Northern	65.0	46.5	18.3
9.	No. 3 Northern	65.0	46.0	16.0
10.	No. 4 Northern	60.8	43.2	24.2

The yield of flour was found to be directly proportional to the weight per bushel of the cleaned wheat. The heavy weight, clean and high grade wheat yielded 68.5 per cent of total flour while the light weight immature wheat yielded only 51.7 per cent. Had the system employed contained an additional stand of rolls about four per cent more flour could have been recovered from the offals and tailings. The results are, however, strictly comparable. The sample of wheat No. 6, which was affected by rust yielded 16.8 per cent less flour than the highest grade and soundest sample, No. 1. The dry matter, nitrogen content, crude protein, ash, and acidity of the samples milled are as follows:

TABLE XII. Composition of Wheats.

Sample No.	GRADE	Dry Matter. Per Cent	Ash Per Cent	Total Nitrogen. Per Cent	Crude Protein. Per Cent
1.	Inspected in, No. 1 Northern	89.30	1.97	1.84	11.49
2.	Inspected out. No. 1 Northern	89.03	2.02	1.84	11.49
3.	No. 2 Northern	88.90	2.07	2.03	12.70
4.	No. 3 Northern	89.30	1.84	1.91	11.92
5.	No. 4 Northern	88.72	1.73	2.00	12.50
6.	Rejected	89.02	2.18	2.00	12.50
7.	No Grade	89.50	1.80	2.00	12.50
8.	No. 2 Northern	87.52	1.91	1.94	12.10
9.	No. 3 Northern	90.04	1.73	1.89	11.80
10.	No. 4 Northern	89.89	1.80	1.93	12.31

The rusted wheat, sample No. 6, contained the largest amount of protein. All of the samples were unusually low in protein due to the climatic conditions, particularly the excess of rainfall during the latter part of the growing season. An excess of water during the growing season appears to have a

tendency to decrease the protein content of all grains. No material difference was observed in the protein content of the various grades of wheat tested. There appears to be quite a wide range in the protein content of rusted wheats, some samples have been analyzed showing as low as 11 per cent and others as high as 19 per cent. Owing to their poor milling and bread making qualities and a tendency toward a high protein content the farmer will find the badly rusted wheat more valuable for feeding purposes than a marketable crop. A large portion of the poorer qualities of rusted wheat as found on the market are ultimately used as feeds.

The patent flours obtained from the milling of the ten samples of wheat were submitted to chemical, technical and baking tests. The results are presented in the following tables:

TABLE XIII. Dry Matter, Protein and Ash Content of Flours.

Sample No.	GRADE.	Dry Matter Per cent.	Ash Per cent.	Protein. Per cent.	Gliadin. Per cent.
1	No. 1 North'n inspected in	86.89	.51	10 34	.98
2	No. 1 North'n inspected out	87.16	.49	10.60	.84
3	No. 2 Northern.....	87.28	.47	8.57	.84
4.	No. 3 Northern.....	87.39	.49	11.10	.90
5	No. 4 Northern.....	87.77	.48	11.08	.80
6	Rejected	87.60	.61	11.20	.88
7	No Grade.....	87.49	.50	11.20	.92
8	No. 2 Northern.....	88.08	.53	11.38	.83
9	No. 3 Northern.....	88.43	.50	10.81	.85
10	No. 4 Northern.....	88.31	.55	11.50	.89

TABLE XIV. Technical Tests of Flour Samples.

Sample No.	GRADE.	Absorbtion. CC.	Dry Gluten. Per cent.	Size of Loaf. Inches.	Comparative Rank.
1	No. 1 Northern, insp. in..	52.3	9.8	22.75x18.50	1
2	No. 1 Northern, insp. out.	52.6	9.6	22.50x18.25	2
3	No. 2 Northern.....	51.6	9.5	20.75x15.75	4
4	No. 3 Northern	52.6	10	22 x17.25	3
5	No. 4 Northern.....	54	10	21.50x17	7
6	Rejected	55	10 5	20.50x16	5
7	No Grade.....	52	10.5	21.25x16.75	6
8	No. 2 Northern.....	54	.....	20.62x15.87	4
9	No. 3 Northern	53	.....	21.12x16.75	3
10	No. 4 Northern.....	52	.....	21.62x16.87	3

Flour samples, Nos. 1 and 2, milled from No. 1 Northern wheat produced the largest size loaf and the best quality of bread, these samples, however, contained less protein and gluten than samples 4, 5, 6 and 7, which produced a smaller sized

and a poorer quality of loaf. The flour from the badly rusted wheat, No. 6, while it contained more total gluten and protein than any of the flours from the standard grades of wheat, was lacking in desirable physical qualities as power of expansion and color. The gluten was abnormal in composition; this is reflected in the low gliadin content of the flour. The rusted wheat produced the poorest quality of bread. Light weight, rust-free wheat, although it makes a poor yield of flour, generally produces one of fair quality and one which contains a gluten of normal properties. The light-weight wheat when badly affected by rust has had its bread making qualities impaired so that it will not make a high grade of flour. The fact that there are many localities where the wheat has not been materially affected by rust makes it possible for the standard grades and brands of flour to be maintained as to quality.

Fig. 183. Heavy Weight Wheat, Upper Row, x 2, 1.
Light Weight Wheat, Lower Row, x 2.1.

FIG. 184.—Glutinous Wheat, Upper Row, x 2.1.
Starchy Wheat, Lower Row, x 2.1.

FIG. 185.—Flour Products obtained in the testing of Wheat.
1. 1st Middlings Flour. 2. 2nd Middlings Flour. 3. Break Flour.
4. Shorts and Feed. 5. Bran (Not Compressed).

FIG. 186.—Experimental Mill used in the Testing of Wheat, and for the Production of Flour used in Nutrition Investigations.

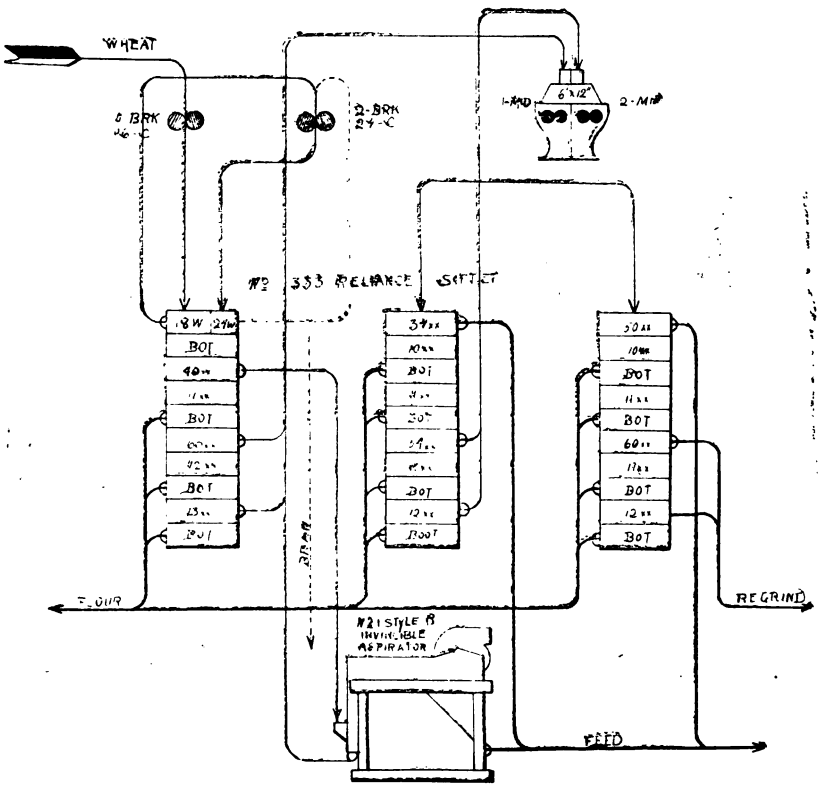


FIG. 187.—Showing the Course which the Wheat follows during the Process of Milling.

Fig. 188. Bake Oven and Sponge Case used in making tests.

FIG. 189.—Bread from Different Grades of Wheat.

1 No. 1 Northern Inspected In. No. 2. 1 Northern Inspected Out. 3. No. 3 Northern 4. No. 2 Northern.

5. No Grade. 6. No. 4 Northern. 7. Rejected.

POULTRY CULTURE IN MINNESOTA.

CHAS. S. GREENE.

In response to numerous inquiries as to the advantages of poultry keeping in relation to other branches of farming in Minnesota, and the proper methods to pursue to insure a profit upon the investment. we have tried in this bulletin to describe some of the conditions necessary to insure success and the easiest way to bring these conditions about. The ideas here presented are based upon our own experience and that of others whom we know to be doing good work along these lines.

We have not as yet conducted many scientific experiments to get exact data pertaining to any particular branches of the business. No apology is offered for this as we have had neither time nor money for this purpose. We know however, that the general farmer is not using even what information is available. It is the privilege and duty of the Agricultural Experiment Station, which is an educational institution, to use every possible means to promote this industry, that it may develop into a more important source of income to farmers and poultrymen in the Northwest. With her natural advantages Minnesota should occupy a place among the foremost poultry producing States in the Union.

By far the larger part of the eggs and dressed poultry on our markets at the present time comes from the farm where poultry are kept only as a side line. We find these fowls are being kept in houses of nearly every conceivable style and generally receiving very little care from their owners. We believe that this state of affairs exists chiefly because of the erroneous idea that poultry keeping is a small business, not worthy of a man's attention. According to the Twelfth Census the eggs and poultry produced in the United States in one year are valued at $281,178,247.00. Minnesota produces about seven and one half million dollars worth of poultry and eggs in a year which could easily be doubled if proper attention were given to this branch of farm work.

A great deal could be said in regard to the profits of the poultry business but here it is only necessary to repeat what has been written before. "Profit with poultry is gained in ex-

act proportion to the care and thought devoted to the business." There is no luck connected with it any more than in any other branch of farming. We would suggest, that unless a person is willing to comply with the conditions of success he had better not venture a very large capital in the poultry business.

LOCATION.

One of the first and most important questions to decide in starting a poultry plant is the location. The factors determining the location are: the markets, soil, and climate. We believe these are here named in the order of their importance. It is of little use to produce a good article if we are out of reach of markets that are willing to pay reasonable prices for our produce. People living near cities and large towns will therefore have an advantage over those living in remote regions. While this should be considered carefully in starting it should not discourage people from keeping poultry because they do not live near a large city. Many large and successful poultry farms ship their produce from one to three hundred miles. By making contracts ahead they are enabled to realize a good profit on the investment.

SOIL.

The soil should be a sandy loam and high enough so that all surface water may drain away. When such a location is not at hand and it is necessary to build upon low or level land, a foundation for the house should be built of brick about two feet high and the inside filled in with earth (preferably gravel or sand) to the top of the foundation and graded up to the same level outside. The ground should be sloping away from the building on all sides. This will materially aid in keepng the house dry. We do not advise locating a house in a bank as it is almost sure to be damp. Dampness must be guarded against in all our dealings with poultry or disease and failure are apt to follow.

CLIMATE.

While it is true that poultry will live and thrive in nearly every clime, we find that about 40 degrees North latitude is best adapted to their requirements. We would prefer a colder climate than this rather than warmer for several reasons. The hot summers in the South furnish ideal conditions for the

rapid multiplication of all kinds of vermin which prey upon the birds. Disease germs are more numerous and seem to develop much faster than in a colder climate. A very hot climate has a depressing influence on laying hens and will greatly retard the growth of chicks, if it does not ruin them entirely. Eggs laid when the weather is moderately cool are of better quality; that is they have what is called "more body" than those laid in hot weather, unless the latter are kept in refrigerators until used.

The cold of the winter, in the northern part of Minnesota is not so difficult to overcome as the heat of a southern climate. Here we can build our houses practically frost proof so that, barring the extra expense of warmer houses, the only disadvantage we have to contend with is the prolonged winters. Usually we are compelled to keep stock housed a little more than five months. During this time we do not allow the birds to go out of the house.

STOCK.

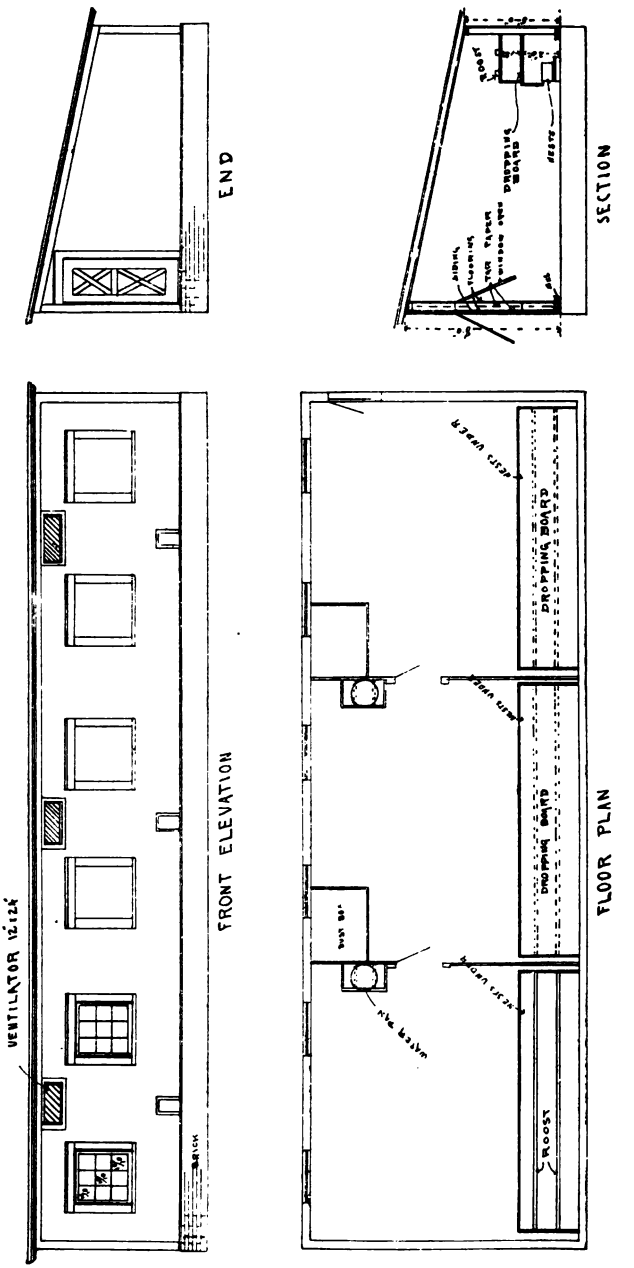
With nearly a hundred varieties of pure bred poultry to choose from we can certainly find one that is suited to our requirements. One breed is enough for any farmer. If he tries to keep more than one breed the result is almost sure to be a mixture which practically ruins his whole flock. There is abundant proof that it will pay every one better to keep pure bred stock than it will to keep mongrels. This is true even if stock is kept solely for market purposes without selling eggs for hatching or stock for breeding purposes. Here at the Experiment Farm we are breeding White Leghorns, White Wyandottes and Barred Plymouth Rocks. The Leghorns are the best layers, and have another advantage in coming to laying maturity at least a month before the other breeds, which makes it possible to hatch them so much later in the spring and bring them to maturity in October or November. In Canada 42 per cent of all the fowls kept are Barred Plymouth Rocks. In England and Ireland the Orpingtons and Dorkings are taking the lead especially for market poultry. Considerable attention has been paid to Buff varieties during recent years. The Buff Plymouth Rocks, Wyandottes, Orpingtons and Leghorns all seem to be growing in favor especially among fanciers. Nearly every breed or variety has some good qualities. If a selection is made with a view of supplying a certain demand for either eggs or meat it will be very easy to find a variety that will produce the desired results.

HOUSES AND RUNS.

A poultry house in this latitude must be warm, dry, light, and well ventilated without draughts. The neglect of any one of these requirements is enough to destroy the usefulness of a flock of birds for the whole season. There are many theories advanced, for building poultry houses, that will not bear a practical test. Great care should be used to have all buildings and fixtures connected with a house as simple as possible thus reducing to the lowest point the labor in caring for the birds.

The two most common plans of building are what are known as the scratching shed plan and the continuous long house. The scratching shed plan is to build a small roosting and laying room and connected with it, a room somewhat larger with an open front facing the south. The floor of this room is covered with straw for the hens to exercise in during the day time. The open front is covered with wire netting to confine the brds. It is also fitted with cloth covered frames hinged at the top to be closed during stormy weather. The object of this plan is to furnish the fowls with fresh air and exercise in a natural way, with a warm place in which to sleep at night. The continuous closed front house with a shed roof sloping to the rear, and fitted with windows enough in front to furnish sufficient light for the fowls is the most common style. There should be no trees, board fence or buildings within 150 feet of the south side to obstruct the sunlight.

We have no proof that one method of building is better than the other. We know that both are being used extensively and with varying success. In this country where the mercury has a range of at least 130 degrees, we do not advise building a house with an open front if winter eggs are desired. Neither do we advise building a house nearly air tight and keeping it closed all winter regardless of the weather. We try to avoid both extremes by building a warm closely built house and ventilating it by a method which will be described under that head. We are unable to state exactly at what temperature a room should be kept for laying hens in cold weather. We know this depends largely upon weather conditions. If it is from 32 degrees to 40 degrees above zero inside the house when the mercury shows 20 degrees to 40 degrees below in the open air, we can feel sure our house is built well enough so we should be able to obtain very good results in eggs. We have never produced eggs profitably in a house whose temperature was ranging much below the freezing point for any considerable length of time. We do not say that this cannot be done,


END
SECTION
FRONT ELEVATION
FLOOR PLAN
VENTILATOR 12x12
ROOST

but that we have never been able to do it. We give here a plan for a house that will comfortably accommodate 150 hens. It is 16 feet by 48 feet on the ground with 7½ feet studs in front and 4 feet studs behind. The foundation is a brick wall, twelve inches thick and from one to two feet high, depending on the lay of the land. The space inside is filled with earth to the top of the foundation before the building is erected. 4x6 inch sills are then placed on the foundation and the studding set two feet apart. The plates are 4x4 inch made by nailing two 2x4's together. The rafters are 2x6 inch placed the same distance apart as the studs. The outside is then covered all over with matched flooring. Over this are two thicknesses of tarred paper which is covered with shingles on the roof and lap siding on the sides. The inside is boarded up with cheap lumber and the space between the rafters and studding is filled with planer shavings or flax straw packed in very tightly. The house can be plastered inside or not as desired.

Another very good plan, and perhaps a better way in a hilly country or where there are good wind breaks, is to build the house four or five feet higher than the dimensions given and instead of packing the roof, construct a floor of cheap lumber six feet above the main floor of the house, leaving a space of two inches between the boards. The space between this loose floor and the roof to be filled with dry straw in the fall and allowd to remain there over winter. When spring comes this can be used for litter on the floor making room for fresh straw for the next season. This furnishes ventilation through the straw overhead. There should be a door in each end of the loft above the straw to be opened when the weather will permit. This house will keep as dry and comfortable as it is possible to make it.

A house of this size should be divided by wire partitions into three pens. Each pen is then long enough to accommodate about 50 birds. There are two windows in each room, set so that the sills are two and a half feet from the floor. Each window contains nine lights of 10x12 in. glass and is hung on hinges at the top. Storm windows are necessary in this climate and are hung outside on hinges at the top the same as the ones that swing in. The storm windows are held open with long hooks and the inside windows are hooked up against the ceiling when the weather is warm enough to permit.

The inside arrangement should be as simple as possible. An alley way in a house is generally only a waste of room that the fowls should use. A person only has to care for a flock of fowls in a house fitted with an alley way to see its disad-

vantages. The most practical arrangement that we have been able to find for a house like this is to first build a platform along the rear of the house, 2 feet from the floor and three feet wide. One foot above this the two roosts are placed by first fastening, in each room, three arms to the wall with hinges. The front end of the arms should have legs one foot long which rest on the platform when in position. The first roost is placed thirteen inches from the wall and the second one fourteen inches from the first and nailed solidly to the arms. These arms or cross pieces being hinged to the back wall make it very easy to raise the front and fasten to a hook in the ceiling so that the roosts are entirely out of the way for cleaning. This platform has a one inch cleat around it. Under the front of the platform and resting on the floor is a bench six inches high, eighteen inches wide and ten feet long. This forms the bottom of the nests. The nests are made continuous, eleven inches square on the inside, eight inches high and without top or bottom. They are set so that the front comes flush with the front side of the bench. The bench is long enough so as to make room for ten nests. This makes the top of the nests ten inches below the platform. A board one foot wide and twelve feet long, hinged to the front edge of the platform, will lap down on the nest box a little, hiding the nests from view and making a partially dark place for the hens to lay in. This is a very important part of the plan. The board can easily be raised when gathering the eggs.

In one corner of the room is a dust box 3x4 feet and kept well supplied with fine dry sand and ashes. The water pans are galvanized iron made any size to suit the number of birds in the pen. We have them four inches high and fifteen inches in diameter and set on a frame fifteen by 28 inches. This frame is placed eighteen inches from the floor. It is made of two long pieces and four short ones. The two center cross pieces are placed ten inches apart to support the pan. The hens jump up onto the two outside slats to drink. A triangularly shaped box is fastened to the wall half an inch above the pan. This box should be six inches narrower than the pan, leaving three inches on either side through which the birds drink. This box being slanting on the top keeps the hens from getting into the pan and the pan being eighteen inches from the floor keeps the hens from scratching dirt into the water. It is difficult to overestimate the value of arranging the water pan in this way as it combines all the advantages to be found in any drinking device, except where running water can be used, and eliminates every objection. A house

built and furnished as above described has been given a thorough test on the Experiment Farm and has proved to be very satisfactory.

ARTIFICIAL INCUBATION.

Artificial incubation has been practiced so many hundred years that the date of its origin cannot be fixed. History, however, teaches us that the Egyptians were among the first people to hatch chickens artificially. They used brick hatching ovens and were very successful but, unlike the Americans, they did not try to hatch the chickens during the whole year. They were content with a hatching period of about two months. The climate of Egpyt has much to do with their success as the temperature of the atmosphere during the hatching period is but little below that required for incubation. A very warm climate makes the natural method impractical as hens become restless and produce very poor results, so it seems that they were driven to it by necessity.

Artificial incubation in this country began in 1870 so that all the progress which has been made in the art has been accomplished during the last 34 years. The first machines put upon the market were very crude and did not produce satisfactory results. This seemed to prejudice many persons against artificial incubation. When the first really practical machine came on the market, in 1878, it had to overcome the bad reputation its precedessors had made. Since that time the progress along this line has been rapid and marked with success. At present there are several patent incubators on the market that are entirely practical. If only a few chickens are to be raised each year by the average farmer, the natural method will generally prove more satisfactory. People who can spend but a small part of their time in caring for the flock will seldom devote enough time and study to make it profitable to invest the extra amount of money required for incubators and brooders and a proper place in which to run them. If a person has a particular liking for poultry and enough time to devote to it, both methods should be tried and the one adopted that best suits the conditions.

SELECTING AND RUNNING INCUBATORS.

It is not necessary to give here explicit instructions for running incubators, as each manufacturer furnishes complete instructions for operating his particular machine, but a few

general rules may be helpful to those who are thinking of buying machines.

The first thing to consider in selecting an incubator or brooder is whether it will hatch or raise chicks when run by a beginner. We know there are several very good machines on the market, and others that are practically worthless. We would therefore recommend testing a new machine before buying it or else buy machines known to be doing good work when run by people who are not interested in their manufacture.

The best place to run an incubator is in a room made for the purpose, either partly or wholly above ground and constructed preferably of stone, brick or concrete and banked up with earth so that the inside of the room will be but slightly affected by changes in the weather.

A house cellar is often a good place to operate an incubator. The room should have an even temperature if the best results are to be expected. Beginners should start as soon as spring opens. Pullets hatched during April and May will develop into the best winter layers. It is much easier to get strong fertile eggs at this time. This is of the utmost importance. The eggs must first be hatchable before good results can be expected.

Select eggs of medium size with a smooth shell and as perfectly formed as possible. There is no way of telling before placing in the incubator whether an egg will hatch or if it will produce a male or female chick.

BROODERS.

Leave the chicks in the incubator until they are all hatched and thoroughly dry, then remove to the brooder. This requires the greatest care so as not to let them become cold. Young chicks that are accustomed to a temperature of 95 degrees or 100 degrees in the incubator will catch cold very easily when first taken out. A cold contracted at this time is almost sure to affect their lungs and they will die of pneumonia in a short time. The brooder should first be heated to a temperature of 90 degrees to 100 degrees, depending on the location of the thermometer and the temperature of the room. After the first week the temperature should be gradually lowered, giving only just enough heat to make the chicks comfortable. The poultryman should study the comfort of the chicks as well as observe the thermometer.

There are two methods of brooding that are used extensively. One is the long brooder house fitted with a heater

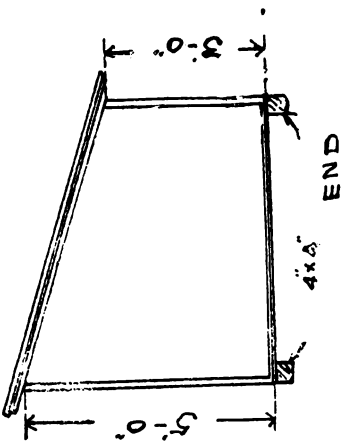
and pipes. This style is used for raising chicks in large numbers in cold weather. It is used almost entirely for brooding ducklngs. As this style is not adapted to the use of farmers we will consider only the individual brooder heated with a kerosene lamp and large enough to accommodate from 50 to 75 chicks. We do not advise putting 100 chicks in one brooder because better results are generally obtained with a smaller number.

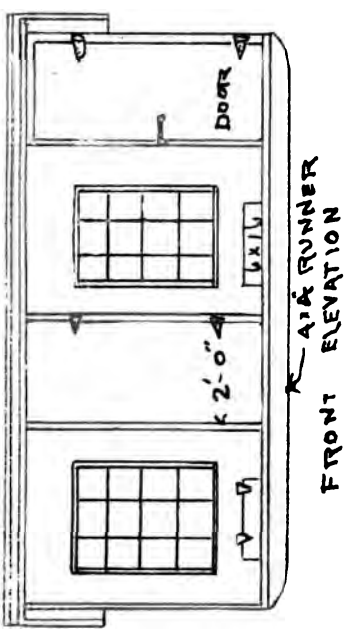
There are four very important features that must be considered in a brooder. First, the heat must be distributed among the chicks in such a way that all are made comfortable; second, ventilation, which has been a very common cause of failure. The system of ventilation must be arranged in such a way that fresh air is warmed first and then forced into the brooder, driving the foul air out. The third consideration is simplicty. It must be easy to clean and operate. A short tme spent unnecessarily, every day with each brooder amounts to hours or even days during the season. The fourth is economy. With oil costing from 8 cents to 18 cents a gallon the brooder that will maintain the required heat with the least oil has a decided advantage. Some brooders require twice as much oil as others. We admit that brooders have been run very successfully without complying with these requirements, but the conditions must have been very favorable. We want a brooder that will do the required work even under unfavorable conditions and in quite cold weather. The careful consideration of the merits of the different machines before purchasing will often make the difference between profit and loss.

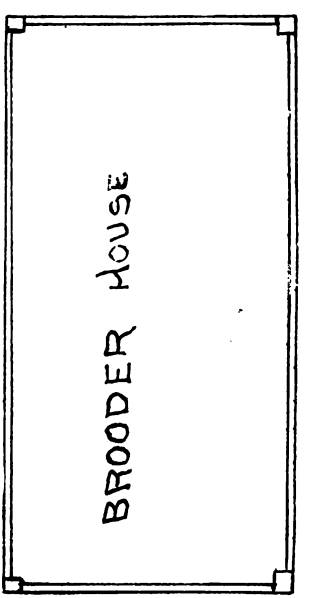
Although there are many so-called out-door brooders on the market we do not recommend their use in this section of the country. There are often several days at a time when very young chicks cannot be allowed out of doors and if confined to a brooder serious results will soon follow. In a warmer climate or very late in the season here, out door brooders will sometimes give good satisfaction, provided they are fitted with a cold brooder attachment in which to confine the chicks when the grass is wet and where they can be fed in rainy weather.

BROODER HOUSES.

The proper place for a brooder is in a house built for the purpose. Each house should contain one or not more than two brooders, and the houses should be placed in a sheltered and well drained place where cold winds cannot strike them. One


3'-0"
END
4"x4"
5'-0"


DOOR
6"x6"
2'-0"
AIR RUNNER
FRONT ELEVATION


BROODER HOUSE

of the best locations for brooder houses is in an orchard or along the south side of a grove or thicket. The trees protect the chickens from enemies to some extent and furnish needed shade during the warm summer days. The houses are placed at least 150 feet apart so that each flock is practically separate from the others. The best and most economical brooder houses that we have been able to devise at present are such as we use here at the Experiment Farm. They are twelve feet long, six feet wide, three feet high in rear and five feet high in front, with a partition in the center dividng the house into two rooms, each six feet square.

The house faces the south and a brooder is set in the northwest corner of each room. Each brooder should accommodate about 50 chicks. This house is built upon 4x4 in. runners so it can be easily moved with a pair of horses. The sills are 2x4's nailed to the runners. The studs and rafters are 2x2 in. placed 3 feet apart except on the south side where extra studs are inserted each side of the windows and doors. There is a window containing six lights of 7x9 in. glass in each room in front of the brooder. There is a door into each room two feet wide and about as high as the house. As this house is only intended to be used through the summer months, no attempt is made to build it warm enough to keep out the frost. The only object being to make the roof, walls, and floor tight and durable. Matched flooring may be used to good advantage for the floor, roof and sides. The roof is then covered with one ply Pariod roofing and the sides with Neponset red rope roofing. This makes a house that is wind and water proof and which will last many years if cared for and kept well painted.

This system of brooding has several advantages. The house furnishes comfortable quarters for chicks during inclement weather. When the chicks are six or eight weeks old and no longer need artificial heat the brooders can be removed and the house used as a summer roosting coop until the stock is ready to go into winter quarters in October. By arranging the houses in this manner we avoid building fences and at the same time chicks cannot crowd much as the houses are far enough apart to prevent it.

RUNS.

When chicks are first placed in these houses a yard about twelve feet square is built in front of each pen. The fence used for this purpose is a light frame, 2½ feet by 12 feet, made out of 1x4 inch material on which is nailed one inch

mesh wire netting thirty inches wide. These hurdles make a light portable fence that is very easy to use. When the chicks are old enough to fly over this fence it is removed and they are allowed free range.

NATURAL INCUBATION.

Quite frequently it happers that hens do not become broody until the best of the season for hatching is past. When this is the case we have always found that the hens did not begin to lay until late in the winter or early spring. The only way out of this difficulty that we know of unless artificial incubation is resorted to, is to give the fowls proper care at all times so they will lay all winter and thus produce early sitters.

As with the artificial method, April and May are the best months in which to hatch, but if necessary the last broods may come og as late as June 15th. These late hatched chicks will do very well if kept separate from older ones. It is very important that we never keep young chicks with older ones as the older ones will crowd the young ones away from the feed and run over them which often stunts their growth.

When a hen which we wish to set becomes broody we remove her to a room especially provided for the purpose and away from hens that are laying. The nest is made in a shallow box about one foot square, by first placing a shovel full of earth in the bottom and over this some fine hay or straw; making the nest slightly concave so the eggs will have very little pressure against each other. Artificial eggs are first placed in the nest and the hen removed to them at night and enclosed in the nest until the next night when she can be released and fed. This process of confining the hen to the nest should be continued until she returns to the nest of her own accord. The eggs she is to hatch should then be given her at night so as to disturb her as little as possible. Whole wheat, corn and grit are kept in boxes where the sitters can eat whenever they come off the nest. Fresh water should be supplied every day and a box of road dust or ashes kept in the room for the sitters to dust in. Several hens may be set in one room if care is taken to see that they go back on their own nest every time. Each hen should be dusted with some good insect powder when she is set and again at the end of the first and second weeks. When this is neglected the chicks are almost sure to be infested with lice which will materially retard their growth and may decrease their number. When all are hatched and dry they should be carefully moved to a coop

located as described for a brooder house; but if the weather is very cold the coop should be located in a barn or under a shed where it can be moved out in the sunlight on pleasant days. In very warm weather the coop should be placed in the shade of a tree. Nothing is better than a good grass run where chickens have not been kept the year before. The coop should be twenty by thirty inches on the ground, eighteen inches high in the rear and twenty-seven inches high in front. It should be made of one inch boards with the cracks battened except the front which is composed of slats two and a half inches apart. These slats are covered with two boards one foot wide. One of these is hinged three inches from the top and the other is hinged at the bottom so that when both are closed there is a space of three inches left at the top for ventilation. This space should be covered by netting to keep out rats. When open, the lowed door serves as a feeding board and the upper one should be fastened on a slant to serve as a sort of porch roof.

The floor, which is separate from the coop, is made to fit the inside of the house loosely. The coop can then be lifted off the floor and cleaned every day. The floor should be covered with some dry sand or dust and over this is put a little chaff or straw. The chicks are given free range after they are two days old, if the ground is dry, but should be prevented from running in wet grass until well feathered.

FOOD AND CARE OF CHICKS.

There are a few principles that must be understood before any directions for the feeding and care of chicks can be successfully followed under varying conditions. First it has been shown that no two fowls are exactly alike. Corn, wheat, or other food stuff grown in one part of the country may be quite different from that grown in another part. There are also many different grades of the same kind of grain. This makes it practically impossible to reduce the feeding of chicks to an exact science. Then, too, the different seasons of the year change the effects of food so that judgment must be the guide in feeding after all printed instructions have been learned.

Another very important item to learn is that how and when we feed makes just as much difference with the results as what we feed.

Chicks require considerable exercise to maintain health and promote growth. During mild weather in summer when free

range is allowed they will take exercise enough naturally, and it would be useless to make them work for their food. When the weather is cold or where they are raised on a limited area, it is necessary to confine them to the house or a very small yard. This condition naturally makes them indolent and they become unprofitable unless we adopt some means of compelling them to exercise. Greater care must be given chickens in confinement because everything that is necessary to their health and growth must be supplied, while chickens that are allowed free range will find for themselves grass, insects and many other things that help to make them thrifty.

When the chicks are first taken from the nest or incubator and placed in the coop or brooder, they should be kept as quiet as possible for at least thirty-six hours. Great care should be used to keep them from straying away and getting chilled. When they are about thirty-six hours old they are fed for the first time. The best food for this purpose is wheat bread dried in the oven until crisp. This is then rolled or ground fine and mixed with about one-fourth of its weight of raw egg. This should then be dried just enough to make it crumbly and not sticky. It can be kept before them constantly the first day and should be fed every two hours the second day. After the second day only one feed a day of this food should be given for two or three weeks. As soon as the chicks have learned to eat it is well to place grit, granulated charcoal and warm water within easy reach. Care should be taken that the grit is very fine so it will go through a sieve ten meshes to the inch. The water should be placed in such a way that the chicks cannot get into it. A saucer six inches across and two inches deep is a very convenient dish for them to drink out of. The water in this dish can be replenished by inverting into the dish a can filled with water and having a small hole less than two inches from the top. This will supply water as fast as it is used up and will also prevent the chicks from getting into the water. After the second day and until the chicks are five or six weeks old they are fed johnny cake two or three times a day, alternating with cracked wheat, pinhead oatmeal, millet seed or cracked corn, all fed together or alternately. If the chicks need exercise the whole or cracked grain can be scattered in litter on the floor. Care should be taken not to feed too much of the johnny cake as they will not work for the grain if they have all the johnny cake that they can eat. This johnny cake is made by mixing five parts cornmeal, one part wheat middlings, and one-half part beef scrap or one part egg (the infertile eggs tested out

of a machine will do) mixed with butter milk and a little soda added. This is stirred quite stiff in a pail. The pail is then covered and set in a kettle of boiling water and steamed two or three hours until thoroughly cooked. Fnough of this can be cooked at once to last two days. When it is cooked in this way there is no crust on it so it is all eaten.

Chicks should be fed every two or three hours for the first three days and then five times a day until they are six weeks old. When more than six weeks old three or four times a day is sufficient. Regularity should be observed at all times in feeding either chicks or fowls. They know when it is feeding time as well as the attendant does and if kept waiting they will not make nearly as rapid growth.

Great care should be exercised in keeping the drinking water clean. If allowed to become dirty the water will poison the chicks and they soon show its effects. It should be kept in the shade in warm weather and changed twice a day when chicks are very young and once a day after they are two weeks old.

Green food should be fed every day from the time the chicks are three days old until they are ten days old if the best results are to be expected. The best green food is young tender grass cut in 1-8 inch lengths. When this is not obtainable raw vgetables such as beets, turnips, potatoes or cabbage can be ground or chopped very fine, and fed once a day. After the chicks are ten days old they can obtain a sufficient supply of green food if allowed the range of a grass plot.

From the time chicks are six or eight weeks old until winter they will do well on free range with very little care. The house should be kept clean and well ventilated. As the chicks grow they require more room. They must not be allowed to become crowded. It is wise to visit the coops at night occasionally to see the exact condition of the birds. The kind of feed that is given during this time is not so important as with the young chicks. A variety of good wholesome foods should be supplied in liberal quantities.

LAYING HENS. FALL AND WINTER CARE.

To produce eggs in paying quantities during the winter months it is first necessary that the stock should be in proper condition not later than November first. Old hens, as a rule, that molt late in the fall cannot be put in condition for laying until the last of January. We rely principally on the pullets hatched the spring previous for our early winter eggs. We

may make one exception to this rule. Yearling hens that molt in August will generally get in condition to lay by December and make very profitable winter layers. They must be fed and cared for so as to hasten molting if they are expected to molt early, as ordinarily a hen will not molt until September. The process of hastening the molt consists of first reducing the feed so as to stop the production of eggs during the last week of July. When they have topped laying and have been kept on about one-fourth of a ration for about three weeks the feed is then increased gradually for a few days until a complete egg producing ration is fed in liberal quantity. At this time one pound of oil meal to each hundred hens or a small feed of sunflower seed every other day can be profitably fed.

Hens and pullets should all be in winter quarters before the cold fall rains or freezing weather. The temperature of the house should be kept above the freezing point but should not be forced above 40 degrees by keeping the house closed at the expense of ventilation. The entire floor of the house should be covered with about six inches of dry clean straw which must be changed as often as it becomes damp or soiled. All whole or cracked grain is scattered in this litter. The variety of grain must depend largely upon its availability and cost. A very good mixture would be one hundred pounds each of whole wheat and cracked corn and fifty pounds of oats. This makes a very good scratching feed for winter. This can be fed to them, all they will eat the first thing in the morning. Hens will always work for feed in the morning as that is when they are most hungry. At eleven o'clock A. M., the mash can be given but it should be very dry, not wet or sloppy. A great variety of mixtures have been used for this mash feed with very good success and we do not pretend to know which is the best. 100 pounds bran, 100 pounds middlings, 100 pounds cornmeal, 100 pounds green cut bone, and 50 pounds peameal make a very good mixture, but hens are very fond of it and should not be fed all they will eat of it. 100 pounds ground oats, 100 pounds ground barley, 50 pounds wheat middlings, and 75 pounds green cut bone or beef scrap is another mixture that has given very good results when fed very dry. A very little hot water can be used in cold weather but too much water will injure the effect of the food. This ground feed should be fed in V shaped troughs about four and one-half inches deep. After they have eaten about two-thirds as much as they care for a very little of the scratching feed can be scattered on the floor to keep the fowls busy. After this is fed they should be supplied with all the green

food they will eat. Mangel-wurtzels are the most palatable of any of the vegetables commonly used. Taking their cost and the ease of keeping them into consideration they will generally prove the most satisfactory of anything for green food in the winter. They are fed by cutting them in two lengthwise and throwing them in the pen on the floor. The fowls will also relish cabbage, turnips and potatoes. A little second growth clover or alfalfa, cut fine and steamed makes a change greatly relished by the hens. This however, cannot be fed in unlimited amounts like the raw vegetables but the quantity must be limited to the requirements of the flock. No exact rule can be given for this as it depends much upon the other food that is given, the breed of fowls, and their condition.

The evening feed is practically the same as the morning feed and given in the same way, except that it is fed in more liberal quantity. The object being to give them all they will eat just before going to roost. They should be fed at least 2 hours before dark, so they will have plenty time to eat before going to roost. Fresh clean water, grit and crushed oyster shell must be constantly before them.

Regularity in feeding is of the greatest importance in the care of either laying hens or growing chicks. They seem to know when it is feeding time as well as the attendant and any diversion from the regular order or time can be quickly noticed in the results obtained.

FINISHING CHICKENS FOR MARKET.

There are two methods of finishing chickens for market that are practiced in both Canada and the United States. One is to place the chicks in crates and let them feed from a trough in front. The other is to remove the chicks from the crate and feed with a cramming machine. Both are very successful in the hands of experts. It seems to be easier to learn crate fattening than it is to learn the cramming system, although better results are claimed for cramming. We made one test of crate fattening last year. Twenty-four well bred Plymouth Rocks were selected and placed in two crates. These crates were each six feet long, twenty inches high and twenty inches wide with doors at the top and divided into three pens, each containing four cockerels.

The crates are made of 1x1 inch strips running lengthwise of the crate and 1½ inches apart except the front where the strips are placed perpendicularly and two inches apart to enable the chicks to put their heads out between them to eat.

They are fed from a shallow trough set two inches from the front of the crate. The crates are set on saw horses twenty inches from the floor so the droppings can drop through the slatted floor onto sand underneath where they can easily be removed. The crates were placed in an open front shed so the chicks had plenty of fresh air without draught. In cold weather of course they should be kept in a fairly warm house.

These chicks were about three months old when the test began and the twenty-four weighed 87.4 pounds. At the end of twenty days they weighed 123.6 pounds making practically a gain of one and a half pounds each in twenty days. These chicks were fed ground oats (with the coarser hulls sifted out) mixed quite wet with butter milk or skim milk and slightly salted. They were fed three times a day for the first two weeks and twice a day thereafter. Care was taken not to feed too much at once, and they were never fed quite as much as they would eat. They were fed grit and charcoal occasionally and watered twice a day from the trough.

It required 5 2-3 pounds of clear ground oats or four pounds of the sifted oats for each pound of gain. With oats at 30 cents a bushel the cost of gain would be 5½ cents a pound. With chickens worth from 10 cents to 15 cents a pound a good profit can be realized. The quality of the meat is improved very much so an extra price can be secured as soon as people learn what crate fattened chickens are. We would recommend that farmers try this method of fattening so they can realize the highest price and be able to market the extra birds in autumn.

MARKETING.

One of the most important details in conducting a profitable poultry plant even if only a very few fowls are kept is to put everything on the market as fresh as possible and in the most attractive condition. Eggs should never be more than a week old. They should be washed perfectly clean and graded for both size and color. If only one breed of fowls is kept the eggs will be very uniform. This adds considerably to their value when it comes to supplying a fine trade.

Each egg should be stamped with the name of the farm where it was produced. This is a guarantee to the customer that it is a first class article which is always in demand at an advanced price.

Chickens and fowls should always be well fattened and dressed because there is never any profit in marketing an inferior article. They should be killed by bleeding from the

mouth and broilers should be dry picked, care being taken to remove all the pinfeathers. Old fowls can be dressed very well by scalding them in water a little below the boiling point and then dipping them quickly into cold water before picking. This makes the feathers stick together so they can be removed much quicker. It also keeps the outside thin skin from peeling off. They should then be cooled thoroughly and packed in boxes. Plain paper is used to line the box and between the layers. Each chicken should be labeled with the name of the producer. Both eggs and poultry should be marketed as soon as possible after they are ready.

TURKEYS.

The high prices paid for turkeys in November and December and the ease with which they may be raised should stimulate a greater interest in turkeys among farmers who can give them a good range.

Turkeys are naturally a half wild bird so they will not bear close confinement. Generally a small flock of from five to eight breeders will do better than a large flock. We let the hens select their own nests in secluded places and then gather the eggs every day to keep them from being chilled. Each hen is given about fifteen eggs and when the young are hatched they are allowed to roam at will. They are fed johnny cake occasionally such as is recommended for chickens. Barley and corn soaked or boiled a few minutes are good feeds for fattening. If the turkeys are kept in a slightly darkened room and fed heavily for about three weeks the quality of the flesh will be very much improved, and they will generally pay for the feed in extra weight.

The winter care of the breeders is very simple. All they seem to require is some whole corn, wheat or barley, grit and water. Twice a day is often enough to feed them. They do not need a warm place in which to roost. They will do better in a rather cool house with plenty of fresh air.

Reprint of Bulletin No. 92.

THE DIGESTIBILITY AND NUTRITIVE VALUE OF COTTAGE CHEESE, RICE, PEAS AND BACON.

HARRY SNYDER.

This investigation forms part of a series undertaken in 1895 to determine the digestibility, nutritive value, relative cost and loss in the preparation of the more common human foods. In former reports are given the results of experiments with potatoes,[1] bread,[2] milk, eggs, cheese, beans, butter,[3] oleomargarine, oatmeal, toast and sugar,[4] and the comparative digestibility of bread made from graham, entire wheat and straight grade flours.[5]

This Bulletin contains the results of five series of digestion experiments carried on during the year 1904 with working men as subjects. The foods, bread, milk, rice, cottage cheese, bacon, peas and sugar were combined in various ways and the actual digestibility of the rations determined. Each experiment was carried on for a period of three days and three men were experimented upon in each test, making in all fifteen separate digestion experiments.

The general plan followed in this work is outlined in former bulletins of this station, to which the reader is referred for more explicit information, including the definition of terms.[6] In brief, the plan has been as follows: One or more foods have been fed for a period of three to four days. All of the food consumed has been weighed and analyzed and all of the excretory products from the body have also been weighed and analyzed. The amount digested and utilized by the body is obtained by subtracting from the nutrients in the food those that are present in the excretory products. The amount digested is expressed in percentage of the nutrients in the total food.

1Minn. Agr. Expt. Station Bulletin No. 42.
2Minn. Agr. Expt. Station Bulletin No. 54.
3Minn. Agr. Expt. Station Bulletin No. 74.
4Minn. Agr. Expt. Station Bulletin No. 86.
5Minn. Agr. Expt. Station Bulletin No. 85.
6Minn. Agr. Expt. Station Bulletin No. 74.

DIGESTION EXPERIMENTS WITH COTTAGE CHEESE.

NOS. 1, 2, and 3, SERIES 1.

In this series of experiments the ration consisted of cottage cheese, bread, milk and sugar. The experiments commenced July 14, 1904, and each one continued for three days, during which time approximately 1.1 lbs. of cottage cheese, 1.16 lbs. bread, 4.12 lbs. milk and .06 lb. sugar were consumed per day by each man.

The cottage cheese was prepared in the following way: Separator skim milk was allowed to sour in a warm room. The milk was then heated to a temperature of about 100°F., and hot water 175°F. added at the rate of about one pint per gallon of milk. The addition of the hot water resulted in more complete coagulation of the milk. After stirring for one or two minutes, the coagulated mass was allowed to settle and then the whey was drained off and the curd collected by straining through cheese cloth. If too much hot water is used, a tough curd results; if the milk is not sour enough, it fails to properly curdle. When of medium acidity and favorable temperature, a soft, fine grained curd is secured. The curd was salted and mixed with cream. The cottage cheese prepared in this way was found to be very palatable and contained a large amount of nutriments in the form of proteids and fats.

The bread used in these experiments was prepared from high grade patent flour similar to that used in former investigations. About an ounce per day of sugar was used in the ration and it was sprinkled over the cottage cheese. The milk was obtained from the Dairy Division of the Experiment Station.

In the first series of experiments, the foods,—milk, sugar, bread and cottage cheese,—were combined so as to supply about 0.4 of a pound of protein, .3 of a pound of fat and 1.1 pounds of carbohydrates per day. While there was no intention of making the ration conform to any dietary standard, incidentally it is to be noted that it practically conforms to the requiremens of a ration for a man at active muscular work, as suggested by Atwater, Voit and others.

In this series of experiments, the main object was to determine the digestibility of the cottage cheese and its influence upon the digestibility of other foods.

The men consumed on an average 1.1 pounds per day of the moist cheese, about six ounces per meal. The cheese supplied over 40 per cent of the total protein, and about 28 per cent of

the total fat of the ration. No digestion disorders were experienced by any of the subjects on account of consuming such a large amount of cottage cheese per day. The men were all employed at hard farm labor, and the ration of which cottage cheese formed an essential part gave entire satisfaction.

The amounts of food consumed during the experiments, and the nutrients which they contained, together with the indigestible nutrients in the feces, are given in Tables Nos. 15, 16 and 17. The weights are recorded in grams, and the approximate amount in pounds, if desired, can be determined by dividing the weight in grams by 453. The tables also give the percentage of nutrients of the entire ration which were digested and utilized by the body.

Table XV. Results of Digestion Experiment No. 1. Man 1.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Sugar	90	.....	.....	90.	.....	359.5
Bread	1490	132.0	10.66	857.4	5.73	4414.0
Cheese	1530	222.7	96.30	100.2	10.35	2994.9
Milk	5000	158.5	243.50	241.7	43.50	4275.0
Total		513.2	350.46	1289.3	59.58	12043.4
Feces (water free)		22.25	12.99	26.58	21.69	433.3
Total amount digested		490.95	337.47	1262.72	37.89	11610.1
Total percent digested		95.66	96.26	97.94	63.60	96.46
Available energy total food		.....	.....	.....	.....	91.05

Table XVI. Results of Digestion Experiment No. 2. Man 2.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Sugar	90	.....	.....	90.00	.....	359.5
Bread	1624	143.80	11.62	934.30	6.25	4811.0
Cheese	1550	225.60	97.56	101.50	10.39	3034.0
Milk	5950	188.60	289.80	287.60	51.77	5087.0
Total		558.	398.98	1413.40	68.41	13291.5
Feces (water free)		29.85	20.97	42.15	31.04	695.9
Total amount digested		528.15	378.01	1371.25	37.37	12595.6
Total percent digested		94.65	94.74	97.02	54.63	94.76
Available energy total food		.....	.....	.....	.....	89.52

Table XVII. Results of Digestion Experiment No. 3. Man 3.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Sugar	90	.....	.....	90.	.....	359.5
Bread	1592	141.00	11.38	916.10	6.13	4714.0
Cheese	1550	225.60	97.56	101.50	10.39	3034 0
Milk	5900	187.10	287.30	285.20	51.33	5045.0
Total		553.70	396.25	1392.80	67.85	13152.5
Feces (water free)		24.42	18.53	32.52	27.53	560.6
Total amount digested		529.28	377.72	1360.28	40.32	12591 9
Total percent digested		95.59	95.32	97.67	59.43	95.73
Available energy total food		.....	.....	.....	.....	90.47

Digestibility of Total Food. Summary of Experiments Nos. 1, 2 and 3.

	Foods	Portein	Fat	Carbohydrates	Available Energy
Man 1...	Bread, Milk, Cottage Cheese and Sugar	95.66	96.26	97.94	91.03
Man 2...		94.65	94.74	97.02	8..5.3
Man 3...		95.59	95.32	97.67	90.47
	Average.....	... 95.30	95.44	97.54	90.36

The average of the three experiments in which cottage cheese formed an essential part of the ration show the cheese to be highly digestible. Over 95 per cent of both the proteids and fats and 97 per cent of the carbohydrates of the ration were digested and utilized by the body. In similar experiments, in which the ration consisted of bread and milk alone, it was found that from 91 to 95 per cent of the protein, 93 to 97 per cent of the fat and 97 to 98 per cent of the carbohydrates were digested, depending upon the individual experimented with. In these experiments, where cottage cheese was combined with bread and milk, the total digestibility of the ration remained practically unaltered. Ninety-five per cent of the fat and proteid of cottage cheese and 97 per cent of the carbohydrates were digested and 90 per cent of the energy was available to the body. These results show that cottage cheese has the same digestibility as milk and other dairy products.

A pound of cottage cheese prepared in the way described contains about .17 of a pound of protein, .08 of a pound of fat and .07 of a pound of carbohydrates. This is as much total nutritive material as is found in the edible portion of many cuts of meat, but not as much as is found in meats containing large amounts of fat. Pound for pound, cottage cheese prepared with cream compares favorably in composition and digestibility with beef and other meats. One hundred pounds of skim

milk and four pounds of cream, containing 20 per cent fat, will make from 15 to 16 pounds or more of moist cottage cheese. At 2 cents per quart for skim milk and thirty-five cents per quart for cream, cottage cheese would cost about 11 cents per pound, and compares very favorably in nutritive value with meats at the same price per pound. Where skim milk can be procured at a low cost, cottage cheese is one of the most economical foods that can be used. The addition of cream to cottage cheese favorably influences both its nutritive value and its palatability without increasing the cost above that of average meats. Upon the farm, where milk is produced, cottage cheese is one of the cheapest foods that can be used. Under such a condition is it more economical to use cottage cheese made with cream than it is to make the cream into butter and purchase meat. Cottage cheese supplies a large amount of protein and fat in a very digestible and palatable form.

DIGESTION EXPERIMENTS WITH RICE. NOS. 4, 5 AND 6. SERIES 2.

In the second series of experiments, Nos. 4, 5 and 6, rice was substituted for the bread of the first series. The ration consisted of cottage cheese, rice, milk and sugar. The same men were employed as were experimented upon in the first series of digestion trials, and the conditions were alike in every respect, except that rice was substituted for bread. The uncooked rice contained 8.55 per cent of proteids, which is somewhat higher than is found in many samples. The flour from which the bread was made contained 11.80 per cent of proteids. The rice contained about 3½ per cent more starch than the flour. The men consumed about 0.8 of a pound per day of rice, and in the first series of experiments about 0.7 of a pound per day of flour in the form of bread. The substitution of the rice for the bread made a slight decrease in the total amount of protein and an increase in the carbohydrates content of the ration.

Each day a weighed quantity of rice was cooked separately for each subject, as it was found that the uncooked rice could be more accurately sampled for analysis than the cooked rice. The cottage cheese prepared for this series of experiments was quite similar in composition to that used in the first series, indicating that when prepared under uniform conditions cottage cheese is fairly constant in composition. In all the experiments, the heats of cumbustion or calories were determined by combustion of the materials in an Atwater-Bertholet bomb calorimeter.

The total amounts of rice and other foods consumed during the experiments, the amounts of nutrients in the various foods, the indigestible nutrients recovered from the feces, and the per cent of nutrients digested, are given in the following tables, Nos. 18, 19 and 20.

Table XVIII. Results of Digestion Experiment No. 4. Man 1.

Food Consumed	Weight of material Grams	Portein (nx6.25 Grams	Fat Grams	Carbo hydrates Grams	Ash Grams	Heat of Combustion Calories
Rice	875	74.81	2.71	681.50	2.88	3372.0
Cheese	906	154.10	65.70	59 00	8.89	1843 0
Sugar	90	.....	.....	90 00	.....	359.5
Milk	4550	145.60	217.50	221.60	39.13	3533.
Total		374.51	285.91	1052.10	50.90	9107.5
Feces (water free)		29.02	10.32	20.22	16.45	407.1
Total amount digested		345.49	275.59	1031.88	34.45	8700.4
Total percent digested		92.25	96.39	98.07	67.68	95.53
Available energy total food		.....	.....	.....	.....	90.39

Table XIX. Results of Digestion Experiment No. 5. Man 2.

Food Consumed	Weight of Material Grams	Portein (n x 6.25) Grams	Fat Grams	Carbo-hydrates Grams	Ash Grams	Heat of Combustion Calories
Rice	1300	111.20	4.03	1013.00	4.29	5010.0
Cheese	1350	229.C0	97.90	87.91	13.25	2746.0
Sugar	90	.....	.....	90.00	.....	359.5
Milk	4820	154.30	230.60	234.70	41.45	3743.0
Total		495.10	332.53	1425.61	58.99	11858.5
Feces (water free)		47.62	16.98	33.20	27.05	6C9.5
Total amount digested		447.48	315 55	1392.41	31.94	11189 0
Total percent digested		90.38	94.89	97.67	54.15	94 36
Available energy total food		.....	.....	.....	.....	89.14

Table XX. Results of Digestion Experiment No. 6. Man 3.

Food Consumed	Weight of Material Grams	Portein (n x 6.25) Grams	Fat Grams	Carbo-Hydrates Grams	Ash Grams	Heat of Combustion Calories
Cheese	1380	234.70	100.10	89.86	13.54	2807.0
Milk	6750	216 00	322.70	328.70	58.05	5241.0
Sugar	90	.....	.....	90.00	.....	359.5
Rice	1125	96.19	3.48	876.30	3.71	4336.0
Total		546.89	426.28	1384.86	75.30	12743.5
Feces (water free)		45.15	12.70	33.61	30.53	604.6
Total amount digested		501.74	413.58	1351.25	44.7	12138.9
Total percent digested		91.74	97.02	97.57	59.46	95.25
Available energy total food		.....	.....	.....	.....	89.89

TABLE XXI. Composition of Foods Used in Digestion Experiments.

	Used in Experiment Series	Dry Matter	Proteids	Fat	Cadbohydrates	Ash	Calories
Flour	1	87.71	11.80	1.06	74.43	.42	3.888
Bread	1	67.5	13.12	1.06	85.25	.57	4.389
Cheese	1	.....	56.25	20.	21.62	2.13	6.220
Milk	1	13.75	3.17	4.87	4.84	.87	.855
Rice	2	87.08	8.55	.31	77.89	.33	3.854
Milk	2	13.71	3.20	4.78	4.87	.86	.776
Cheese	2	31.75	53.56	22.84	20.51	3.09	6.407
Bread	3	87.82	8.27	.38	78.85	.32	3.833
Pea Soup	3	19.35	24.97	1.24	67.06	6.73	4.928
Bacon	3	14.03	3.27	4.85	5.11	.80	.859
Bread	4	65.82	13.68	1.40	83.90	1.02	4.457
Pea Soup	4	17.60	24.59	.81	91.98	2.62	4.210
Bacon	4	90.48	35.68	49.22	.....	5.58	6.580
Cheese	5	41.44	52.91	25.77	17.10	4.22	6.527
Bread	5	66.6	13.65	1.40	84.29	.66	4.575
Bacon	5	95.18	25.25	64.03	.....	5.90	7.478

(Figures for composition of bread and peas and cheese on dry matter basis)

TABLE XXII. Nitrogen Balance.

Experiment No.	Total Nitrogen in			Gain
	Food	Feces	Urine	Grams.
1	82.16	3.48	75.83	.95
2	89.34	4.77	66.03	6.18
3	88.36	3.90	77.63	2.27
4	59.86	4.64	55.16	.02
5	79.12	8.46	65.74	1.64
6	87.39	7.32	70.60	3.19
7	51.90	6.69	38.70	2.17
8	67.78	8.19	54.16	.14
9	69.86	8.94	53.03	2.76
10	76.35	12.77	46.61	5.65
11	79.26	28.36	48.90	.68
12	87.40	14.09	58.69	4.87
13	118.14	7.40	71.26	13.16
14	148 26	7.94	88.05	17.42
15	159.08	8.26	99.34	17.16

Digestibility of Total Food. Summary of Digestion Experiments Nos. 4, 5 and 6.

	Foods	Protein Per cent	Fat per cent	Carbohydrates Per cent	Available Energy Per cent
Man 1...	Rice, Cheese, Sugar, Milk	92.25	96.39	98.07	90.39
Man 2...		90 38	94.89	97.67	89.14
Man 3...		91.74	97.02	97.57	89.89
	Average.....	91.46	96.10	97.77	89.81

The substitution of the rice for the bread resulted in lowering the digestibility of the protein of the ration to the extent of about 4 per cent. In a former investigation[7] the addition of 20 per cent of wheat starch to bread resulted in lowering the digestibility of the protein to the extent of about 3 per cent. It has also been observed that breads made from white flour of high protein content were more completely digested than breads made from flour of low protein content[8]. In this respect rice resembles wheat flours of low protein content, inasmuch as the protein is less completely absorbed than in the case of flours of high gluten content.

Rice is commonly called a digestible food. It is a food that, when well cooked, is easily digested, but it is not as completely digested as wheat bread. It has, nevertheless, a high food value, but at the same price per pound as wheat flour it furnishes less nutritive material than bread. The digestibility of bread has been determined in a number of digestion experiments, and it has been found that, when bread is made from straight grade flour, about 88.6 per cent of the proteids and 97.7 per cent of the carbohydrates are digested.[9]

In these experiments, in which rice formed an essential part of the ration, if corrections be made for the digestibility of the other foods with which the rice was combined, it will be found that about 83 per cent of the rice proteids were digested and 98 per cent of the carbohydrates, and that about 90 per cent of the total energy was available to the body.

Rice is a food which supplies to the body a large amount of digestible carbohydrates. A pound of rice like the sample used contains .07 of a pound of digestible protein and .76 of a pound of digestible carbohydrates, which is about .04 of a pound less of protein and more of carbohydrates than is present in wheat flour. When extensively used in the dietary, rice should be combined with foods of high protein content, as meat, cheese and the legumes. Rice is a food that is easily digested, but some of the nutrients, as protein, are not as completely digested as in case of cereals of higher protein content. The rice samples used in these digestion trials were selected types of American grown rice, and the analyses show that they contained a larger amount of nutritive material than is present in average imported rice,—being equal in food value to flours of low gluten content. In these experiments, where the rice was combined with the cottage cheese, milk and sugar, the

7U. S. Dept. of Agr., Office of Experiment Stations, Bul. 101.
8U. S. Dept. of Agr., Office of Experiment Stations, Bul. 167.
9U. S. Dept. of Agr., Year Book 1903, pp. 347-362.

ration gave entire satisfaction and the rice supplied over 36 per cent of the total energy of the ration.

DIGESTION EXPERIMENTS WITH RICE AND PEAS, NOS 7, 8 AND 9. Series 3.

In the third series of experiments, peas were substituted for cottage cheese; in all other respects, however, the ration was the same as for the second series. The peas were thoroughly cooked for twelve hours; at first rapidly over a burner and then in an oven for several hours, until they were thoroughly disintegrated, forming a porridge of thick soup. The ration consisted of pea porridge, rice, sugar and milk. The men consumed per day about six ounces of the dry peas made into a porridge containing about 82 per cent of water. Both the dry peas and the pea porridge were analyzed, and the dry matter showed the presence of nearly 25 per cent of proteids and 70 per cent of carbohydrates. Nearly one-third of the total protein was supplied by the peas and over one-half of the carbohydrates by the rice. This ration contained two extreme types of food, peas a nitrogenous and rice a starchy food. About one ounce per day of sugar was used, as in all the preceding experiments. This ration, in which rice and peas formed an essential part, gave entire satisfaction and caused no digestion disorders.

The total amounts of pea porridge, rice and other foods and the nutrients which they contained, together with the amounts of indigestible nutrients in the feces and the percentage of nutrients digested, are given in the following tables, Nos. 23, 24 and 25.

Table XXIII. Results of Digestion Experiment No. 7. Man 1.

Food Consumed.	Weight of material Grams	Protein (n x 6.25 Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Pea soup	2355	113.80	5.64	305.63	30.67	1904.0
Rice	900	74.43	3.42	709.70	2.88	3391.0
Sugar	90	.....	.....	90.00	.....	359.5
Milk	4200	137.30	203.70	214.60	33.60	3480.0
Total		325.53	212.76	1319.93	67.15	9134.5
Feces (water free)		41.75	9.70	37.63	18.92	490.1
Total amount digested		283.78	203.03	1282.30	48.23	8644.4
Total percent digested		87.18	95.44	97.15	71.82	94.64
Available energy total food		.....	.....	.....	.....	90.18

Table XXIV. Results of Digestion Experiment No. 8. Man 2.

Food Consumed	Weight of Material Grams	Portein (n x 6.25 Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Pea soup	2880	139.10	6.89	373.74	37.51	2329.0
Rice	1200	99.24	4.56	946.20	3.84	4521.0
Sugar	90	.....	.....	90.00	.....	359.5
Milk	4750	155.30	230.40	242.70	38.00	3935.0
Total		393.64	241.85	1652.64	79.35	11144.5
Feces (water free)		51.22	9.05	46.67	23.06	616.9
Total amount digested		342.42	232.80	1605.97	56.29	10527.6
Total percent digested		86.99	96.26	97.18	70.94	94.46
Available energy total food			.....	.....	.....	90.05

Table XXV. Results of Digestion Experiment No. 9. Man 3.

Food Consumed	Weight of Material Grams	Portein (n x 6.25 Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Pea soup	2450	118.40	5.87	317.88	31.91	1981.0
Rice	1200	99.24	4.56	946.20	3.84	4521.0
Sugar	90	.....	.....	90.00	.....	359.5
Milk	6750	220.70	327.40	344.90	54.00	5592.0
Total		438.34	337.83	1698.98	89.75	12453.5
Feces (water free)		55.89	18.53	46.64	25.95	721.2
Total amount digested		382.45	319.30	1652.34	63.80	11732.3
Total percent digested		87.25	91.56	97.25	71.09	94.21
Available energy total food			.....	.....	.....	89.81

Digestibility of Total Food. Summary of Digestion Experiments Nos. 7, 8 and 9.

	Foods	Portein	Fat	Carbohydratees	Available Energy
Man 1...	Rice, Peas,	87.18	95.44	97.15	90.18
Man 2...	Milk, Sugar,	86.99 87.25	96.26 91.56	97.18 97.25	90.05 89.81
Man 3...	Average.....	87.14	94.42	97.19	90.01

TABLE XXVI. Composition of Feces.

Experiment No.	Man	Portein	Fat	Ash	Carbo-hydrates	Calories
1	1	26.19	15.66	26.13	32.02	5.221
2	2	24.07	16.91	25.03	33.99	5.612
3	3	23.71	17.99	26.73	31.57	5.443
4	1	38.18	13.58	21.64	26.60	5.356
5	2	42.31	11.89	21.38	24.42	5.321
6	3	37.01	10.41	25.02	27.56	4.956
7	1	38.66	8.98	17.52	34.84	4.578
8	2	39.40	6.96	17.74	35.90	4.480
9	3	38 02	12.60	17.65	31.73	4.747
10	1	55.09	10.32	7.71	26.88	6.235
11	2	64.01	12.11	7.78	16.10	5.564
12	3	50.31	7.90	8.49	33.30	5.184
13	1	47.66	21.64	10.89	19.81	5.884
14	2	47.67	26.81	11.12	14.40	5.930
15	3	47.37	26.36	12.38	13.89	5.820

TABLE XXVII. Composition of Urine Samples.

Experient No.	Man	Total Nitrogen Per Cent.	Specific Gravity
1	1	2.24	1.021
2	2	2.16	1.03
3	3	2.33	1.03
4	1	1.22	1.022
5	2	1.25	1.024
6	3	1.41	1.026
7	1	.90	1.023
8	2	1.11	1.022
9	3	1.20	1.026
10	1	1.16	1.022
11	2	1.33	1.029
12	3	1.26	1.023
13	1	1.67	1.024
14	2	2.13	1.03
15	3	1.61	1.025

In these experiments, in which peas and rice formed a large part of the ration, 87.1 per cent of the protein, 94.4 per cent of the fat and 97 per cent of the carbohydrates were digested, and 90 per cent of the energy, measured in calories, was available to the body. The substitution of the peas for the cottage cheese of the second ration lowered the digestibility of the protein of the ration 4 per cent. When corrections are made for the digestibility of the other foods with which the peas were combined, the peas alone were found to have the following average digestibility:

Protein 80.04
Carbohydrates 96.20

The proteids of peas are not as completely digestible as the proteids of the cereals, particularly of wheat flour. Although the proteids in peas are less digestible than in cereals, the large total amount makes nearly twice as much total available protein in peas as in cereals. Peas contain a large amount of protein. A pound of peas costing 8 cents contains .17 of a pound of digestible protein, which is as much as is found in the edible portion of any of the meats.

In former digestion trials, where beans[10] were used, it was found that about 80 per cent of the protein and fat and 96.2 per cent of the carbohydrates were digested by working men. The same results were obtained in these digestion trials with peas. The beans were combined in a ration with bread, milk and butter, while the peas in these trials were combined with rice, milk and sugar. Peas and beans, when combined under similar conditions, have the same digestibility and supply the body with practically the same amounts of nutritive substances. The statements made in the former work in regard to the digestibility, nutritive value and cost of beans also apply in general to peas. As a cheap source of protein, peas are valuable in the dietary, particularly for combination with starchy foods, making a more balanced ration.

DIGESTION EXPERIMENTS WITH BACON AND PEAS, NOS. 10, 11 and 12. SERIES 4.

In this series of experiments, the ration consisted of peas, bacon and bread. The object of this and of the next series was to determine the digestibility and nutritive value of bacon, and incidentally to make a further study of the influence of peas and cottage cheese when combined with other foods.

The bacon used in these experiments was cured at the meat house of the Minnesota Experiment Station by the Division of Animal Husbandry. It was lean bacon of good quality, such as could be prepared and cured on any farm.[11] The bacon was cut into thin slices and baked until crisp and brown. All of the bacon fat was used in the ration. A composite sample of the bacon used in each of the series of experiments was made and analyzed. The bacon contained less water, more protein or lean meat, and less fat than is present in many samples. The average of the two samples showed about 7½ per cent

10Minn. Agr. Expt. Station, Bul. No. 74.
11 U. S. Dept of Agriculture, Farmers Bulletin No. 183.

water, 30 per cent protein and 57 per cent fat. As the analysis indicates, it was distinctly a type of lean bacon.

The bacon supplied over 95 per cent of the total fat of the ration. Peas and rice contain but little fat. It was the intention to have the protein supplied mainly by the peas and bread, but on account of the lean character of the bacon, over half of the total protein was supplied by this material. No sugar or milk was used in this series of experiments.

The men consumed on an average about nine ounces per day of bacon, due largely to the ration being confined to only three food articles. The ration produced no digestion disorders. In the case of Man No. 2, the charcoal marker failed to work satisfactorily, and as a result a sharp separation of the feces for the experimental period was not secured. For this reason the digestion coefficients of the ration of Man No. 2 are not included in the averages.

In Tables 28, 29 and 30 the usual data in connection with the digestion experiments is given.

Table XXVIII. Results of Digestion Experiment No. 10. Man 1.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Pea Soup	2700	116.85	3.83	342.05	12.45	2000.6
Bread	1383	124.53	9.65	766.83	9.28	4057.2
Bacon	660	235.30	324.80	.....	36.83	4342.8
Total		476.68	338.28	1108.88	58.56	10400.6
Feces (water free)		77.13	14.45	37.63	10.80	872.9
Total amount digested		399.55	323.83	1071.25	47.76	9527.7
Total percent digested		83.81	95.73	96.61	81.56	91.61
Available energy in total food		.....	.....	.....	.....	85.88

Table XXIX. Results of Digestion Experiment No. 11. Man 2.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Pea Soup	2300	99.54	3.27	291.40	10.61	1704.2
Bread	1175	105.80	8.20	651.50	7.89	3447.0
Bacon	813	290.10	400.20	.....	45.30	5350.0
Total		495.44	411.67	942.90	63.80	10501.2
Feces (water free)		177.31	33.54	44.60	21.55	1541.2
Total amount digested		318.13	378.13	898.30	42.25	8960.0
Total percent digested		64.21	91.85	95.27	66.22	85.33
Aailable energy in total food		.....	.....	.....	.....	79.45

Table XXX. Results of Digestion Experiment No. 12. Man 3.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Pea Soup	3200	138.50	4.55	405.40	14.75	2371.07
Bread	1375	124.80	9.50	762.40	9.20	4033.59
Bacon	795	283.70	391.30	.....	44.30	5231.00
Total		547.00	405.35	1167.80	68.25	11635.66
Feces (water free)		87.54	13.75	57.94	14.67	902.02
Total amount digested		459.46	391.60	1109.86	53.58	10733.64
Total percent digested		84.00	96.61	95.04	78.51	92.25
Available energy in total food		.....	.....	.....	.....	88.29

Digestibility of Total Food. Summary of Digestion Experiments Nos. 10, 11 and 12.

	Foods	Protein	Fat	Carbohydrates	Available Energy
Man 1....	Bacon. Peas and Bread	83.81	95.73	96.61	85.88
Man 3....		84.00	96.61	95.04	88.29
	Average....	83.90	96.17	95.82	87.08

In this series of experiments, where the ration consisted of bacon, peas and bread, 83.9 per cent of the protein, 96.17 per cent of the fat and 95.82 per cent of carbohydrates were digested. Since over 95 per cent of the fat of the ration was supplied by the bacon, the average for the digestibility of the total fat (96.17 per cent) can be taken with a fair degree of accuracy as representing the digestibility of the bacon fat. This is a high coefficient of digestibility. The digestibility of the protein can be discussed more advantageously in conjunction with the next series of experiments in which bacon forms an essential part.

DIGESTION EXPERIMENTS WITH COTTAGE CHEESE AND BACON, NOS. 13, 14 AND 15. SERIES 5.

In this series of experiments, the ration consisted of cottage cheese, bacon, sugar and bread; the cottage cheese was substituted for the peas of ration No. 4, and the bacon for the milk of ration No. 1. The average of the three digestion experiments shows a high degree of digestibility of the ration as 94.42 per cent of the protein, 96.79 per cent of the fat and 97.57 per cent of the carbohydrates were digested, and 89.57 per cent of the energy was available to the body. In ration No. 4,

where the fat was supplied largely by the bacon, 96.17 per cent was digested, which is practically the same digestibility as was found in ration No. 5, in which the fat was in part derived from the cream used in the preparation of the cottage cheese, and in ration No. 4, where the fat was supplied entirely by the milk and the cheese.

Compared with other foods, bacon fat has a high coefficient of digestibility. The proteids of bacon were also found to have a high digestion coefficient. In ration No. 4, in which the bacon was combined with peas, it was found that 83.9 per cent of the protein of the entire ration was digested, while 94.4 per cent was digested when the peas were replaced with cottage cheese. Making the necessary corrections for the digestibility of the foods with which the bacon was combined, it was found that the bacon proteids have a digestion coefficient of about 92 when combined with cottage cheese and bread, and a much lower digestibility when combined with peas. While the bacon proteids have a high digestibility, they are not as completely digested as the fats.

Table XXXI. Results of Digestion Experiment No. 13. Man 1.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Cheese	1910	418.80	203.90	135.3	33.40	5166.0
Bacon	770	194.42	493.03	.....	45.43	5758.0
Sugar	90	.....	.....	90.00	.....	359.5
Bread	1420	129.10	10.03	800.30	6.29	4327.0
Total		742.32	706.96	1025.60	85.12	15610.5
Feces (water free)		46.23	20.99	19.22	10.56	570.8
Total amount digested		696.09	685.97	1006.38	74.56	15039.7
Total percent digested		93.77	97.03	98.13	87.59	96.34
Available energy in total food		.....	.....	.....	.....	90.40

Table XXXII. Results of Digestion Experiment No. 14. Man 2.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Cheese	2838	622.20	303.10	201.10	49.63	7676.0
Bacon	770	194.42	493.03	.....	45.43	5758.0
Sugar	90	.....	.....	90.00	.....	359.5
Bread	1251	113.70	9.00	705.10	5.50	3812.0
Total		930.32	805.13	996.20	100.56	17605.5
Feces (water free)		49.58	27.88	14.48	11.56	616.72
Total amount digested		880.74	777.25	981.72	89.00	16988.78
Total percent digested		94.67	96.54	98.55	88.56	96.50
Available energy in total food		.....	.....	.....	.....	88.89

Table XXXIII. Results of Digestion Experiment No. 15. Man 3.

Food Consumed	Weight of Material Grams	Protein (nx6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Cheese	2080	653.40	318.20	211.2	52.10	8060 0
Bacon	885	223.46	566.66	90.0	52.21	6618 0
Sugar	90	.....	.....	.....	.....	359.5
Bread	1345	122.30	9.45	758.1	5.96	4098.0
Total		999.16	894.31	1059.3	110.27	19135.5
Feces (water free)		51.63	28.73	15.0	13 49	634.4
Total amount digested		947.53	865.58	1044.3	96.78	18501.1
Total percent d.gested		94.83	96.79	98.59	87.77	96.69
Available energy in total food		.....	.....	.....	.....	89.42

These digestion experiments with bacon show that it yields a large amount of available energy to the body. When burned in the bomb calorimeter, the bacon yielded from 6.5 to 7.4 calories per gram, due to the presence of the large amount of fat. Starch and the carbohydrates yield 4.2 calories per gram, the fats al out 9.2. Allowing 5 per cent for waste, a pound of bacon will contain from .1 to .3 of a pound of digestible protein, and from .4 to .6 of a pound of digestible fat, which is about two-thirds as much as is found in butter.

Lean bacon has a unique value in the dietary. It furnishes as much digestible protein as other meats and nearly twice as much fat, making the total nutrients and available energy derived from bacon much larger than from other meats. Bacon fat is easily digested and when combined with other foods it appears to exert a favorable mechanical action upon digestion.

In each of the digestion experiments, the income and outgo of nitrogen was determined and a nitrogen balance made. In nearly all of the experiments there was a gain of from .2 to 17. grams of nitrogen per day, showing that all of the rations supplied the requisite amount of protein. The experimental period, however, was too short to warrant definite conclusions being drawn in regard to the income and outgo of nitrogen in the food. The gains and losses in the weights of the subjects were within narrow limits.

The Experiments taken as a group show:

That cottage cheese prepared from skim milk and enriched with cream is a cheap, digestible and nutritious food, and when the materials for its preparation are produced on the farm it is one of the most economical foods that can be used. At two cents per quart for skim milk and 35 cents per quart for cream cottage cheese compares favorably with meats at 11 cents per pound.

That rice is easily digested when well cooked, but is no more completely digested than other cereal foods. In these experiments the carbohydrates (starch) of rice were more completely digested than the proteids, but the proteids of rice were not as completely digested as the proteids of wheat bread. The samples of American grown rice used in these experiments supplied nearly as much protein as bread made from low gluten content flours, but at a greater cost. Rice is a food which supplies a large amount of carbohydrates and can be used to best advantage when combined with such foods as peas, cottage cheese and meats, which are rich in protein.

That when peas are used in the ration, they supply a large amount of protein. This is because of the high percentage which they contain, although the proteids of peas are not as completely digestible as the proteids of rice and other cereals. Peas supply the body with about the same amount of available nutrients as beans. When judiciously combined with other foods, peas form one of the cheapest sources for obtaining proteids to make better balanced rations.

The actual digestibility of rations in which milk is used is higher than the calculated digestibility of the individual foods, showing that, when combined with other foods, milk exerts a favorable influence upon digestibility.

That lean bacon in a ration supplies a large amount of digestible nutrients and available energy. Over 96 per cent of the bacon fat was digested and absorbed by the body. Lean bacon contains as much protein and about twice as much digestible fat as other meats, making it at the same and even at a higher price per pound a cheaper food than other meats.

INDEX

A

Page

Acronycta impressa 42
Agricultural Committee II
Agricultural Division VII
Agrilus ruficollis 51
Agrotis ypsilon 77
Alypia octomaculata 72
Ampelophaga myron 71
Amphicerus bicaudatus 66
Anarsia lineatella 74
Anasa tristis 80
Angumois Grain Moth 42
Animal Husbandry Division XI
Anomola marginata 54
Ant Hills in Lawns 179
Anthonomus signatus 52
Aphis, Black, on Violets 189
Aphis cucumeris 80
Aphrophora 4-nota 67
Apple Twig Borer 66
Arctomys monax 162
Arsenate of Lead 115
Arvicola 148

B

Bacon, Digestion experiments with 270, 272
Barn Swallow 132
Basswood, Galls on 185
Bay-Winged Bunting 134
Buds, common 128
Blight of potatoes defined 1
Board of Regents II
Bolting-Cloth Beetle 46
Bordeaux Mixture for potato blight and rot 5
Borer, Stalk 51
Bordeaux Mixture 83, 115
Box Elder, Gallmakers on 185
Blackberry Insects 47
Black-capped Titmouse 135
Blight on Melon 83
Blue Bird 129
Bracon brevicornis 36
Bracon hebetor 36
Bramble Crown Borer 49
Bridge-grafting 157, 164

Brooder Houses 248
Brown Aphis on Violets 189
Bud Moth 52
Bulletins Published during the Year IV
Bumble Flower Beetle 73
Byturus unicolor 52

C

Cabbage Maggot 172
Cabbage Worm 174, 178
Cacoecia rosaceana 54
Cadelle 46
Calandria granaria 41
C. oryza 41
Cane Borer, Red-necked 51
Caterba catenaria 53
Cecidomyia aceris 172
C. negundinis 186
C. robiniae 188
Chain- dotted Geometer 153
Chemical Division IX
Chickadee 135
Chickens, marketing 257
Chicks, Food and Care of 252
Chinch Bug 15
Chremylus rubiginosus 36
Combination of Humus with Phosphates in soils 205
Combination of Humus with Potash of soils 208
Composition of Heavy and Light Weight Seeds 218
Confused Flour Beetle 43
Corn, Glutenous and starchy 221
Correspondents, Reports of 121
Corrosive Sublimate Treatment for scab 8
Cottage Cheese, Digestibility and Nutritive Value of.....260 272
Cottony Maple Scale 67, 181
"Cotton-tail" 149
Craponius inaequalis 74
Cryptorhyncus lapathi 115
Crop rotation 192
Cucumber Insects 80
Cucumber Beetle, Striped 81
Cucumber Flea Beetle 82
Currant and Gooseberry Insects 56
Currant Borer, Imported 56
Currant Worm, Imported 58
Currant Caterpillar, Spiny 61
Currant Fly 63
Currant Fruit Worm 63
Currant Plant Louse..... 59
Currant Span Worm 60
Cut Worms 77, 171

D

Dairy Division IX
Desmia maculalis 69
Diabrotica, 12 Spotted 82
Diabrotica, 12 punctata 82

Diabrotica vittata 81
Digestion Experiments 259
Directors Report V
Downy Woodpecker 136
Dust Sprayers 106

E

Echocerus maxillosus 44
Eight-spotted Forester 72
Empoasca albopicta 59
Empoasca mali 91
Entomology Division XI
Ephestia kuehniella 17
Euphoria inda 73
Epitrix cucumeris 82
English sparrow 142
Eupithecia interruptofasciata 63
Eudemis botrana 73

F

False Chinch Bug 16
Farm manure 192
Fidia viticida 64
Field Mice 144, 153, 156
Financial statement V
Flax Seed, light and dark colored compared 226
Flea-like Negro Bug 55
Flicker 137
Flower Garden, Entomological Suggestions for the 177
Food Habits of Some of Our Common Birds 128
Formula for Dry Bordeaux Mixture 6
Formula for wet Bordeaux Mixture 5
Frit Fly 14

G

Geomys bursarius 146
Glutenous and Starchy Grains 219
Golden-winged Woodpecker 137
Gooseberry Fruit Worm 62
Gooseberry Insects 47
Gophers, Field Mice, etc 144
Gopher, Gray 154, 158
Gopher, Pocket 146, 153, 158
Gopher, Thirteen-lined 151, 157
Gopher Gun 160
Gopher Trap 160
Grain Plant Lice 190
Grains, heavy and light weight 214
Granary Weevil 41
Grape Insects 63
Grapta comma 61
Grape-vine Fidia 64, 67
Grape-vine Flea Beetle 68
Grape-vine Phylloxera 63
Grape Curculio 74
Grape Leaf Folder 69

Grape Leaf Hopper 70
Grape "Thrip" 70
Grape-vine Sphinx 71
Grass Finch 134
Ground Squirrel 154, 158

H.

Haltica chalybea 68
Harpalus pennsylvanicus 79
Heavy and Light Weight Grains 214
Hens, laying, Fall and Winter care 254
Hessian Fly 13
High-hole 137
Horticultural Division VIII
Hydraecia nitela 51

I

Idechthis ephestiae 36
Identification of insects 124
Incubation, artificial 246
Incubation, natural 251
Indian Meal Moth 42
Influence of crop rotations on fertility of soil 192
Inspection of Nurseries 119

K

Kero-water Sprayers 104
Key to Insects Affecting Raspberries, Blackberries, Currants, etc.. 47

L

Lachnosterna fusca 76
Leaf Bug, Four-lined 60
Leaf Hopper 59
Leaf Hopper, Work Against 84
Leaf Roller, Oblique 54, 77
Lepus americanus 149
Lepus campestris 148
L. nutalli sylvestris 149
Letter of Transmittal III
Light and Dark Colored Flax Seeds 226
Light-loving Anomala 54, 68
Losses of Nitrogen during humification 209
Louse, Melon 80
Lygaeus turcicus 16
Lygus pratensis 53

M

Macrodactylus subspinosus 69
Marsh Hawk 140
May Beetle 76
Meadow Lark 133
Meal Snout Moth 43
Mediterranean Flour Moth 17
Melon Blight 83
Melon Louse 80

Melon Insects 80, 83
Meromyza americana, Fitch 15
Mice Field 144, 153, 156
Mildew on Roses 179
Milling, Tests of Wheat 232
Mole 145, 154, 163
Mottled Willow Borer 115

N

Nematus ventricosus 58
Night Hawk 139
Nitrogen in Humus 210
Northeast Experiment Farm XIII
Northwest Experiment Farm XIII
Nozzles 98
Nursery Inspection 119
Nutrients in Heavy and Light Weight Seeds 218
Nysius angustatus 16

O

Oats, Glutenous and Starchy 224
Oberea bimaculata 50
Oecanthus, sp 49
Officers of Station II
Onion Maggot 174
Oscinis soror, Macq 14

P

Paecilocapsus lineatus 60
Pale Brown Byturus 52
Peas, Digestion Experiments with 267, 270
Pelidnota punctata 72
Pigeon Woodpecker 137
Phoebe 130
Phoxopteris comptana 77
Phyllotreta vittata 78
Phylloxera vastatrix 63
Pitchy-legged Otiorhyncus 75
Plant Bug, Tarnished 53
Plant food of soils 198
Plant lice 177
Plea for Some of Our Common Birds 128
Plodia interpunctella 42
Plum Curculio, an Enemy to Apples 109
Polychrosis viteana 73
Poplar Borer, Striped 184
Potato Blight 175
Potato Bug 175
Potatoes at University Farm 1
Potatoes, Seedling 9
Potato yields 2
Poultry Culture in Minnesota 239
Poultry Division XII
Poultry Houses and Runs 242
Prionus laticollis 48
Production of Humus in soils 203

Publications of Experiment Stations for Fiscal year ending June 30th, 1905. IV
Pulvinaria innumerabilis 181
Pyralis farinalis 43

R

Rabbits 144, 148, 152, 155
Rabbit, Jack 144, 148, 152, 155
Rabbit, Cottontail 144, 148, 152, 155
Raspberry and Blackberry Insects 47
Raspberry Cane Borer 50
Raspberry Dagger Moth 53
Raspberry Fruit Worm 55
Raspberry Geometer 55
Red Headed Systena 71
Remedies for Rabbits, Mice, etc 154
Reports of Correspondents 121
Rhopalosiphum violae 189
Rice, Digestion Experiments with 263, 267
Rice Weevil 41
Root Borer, Giant 48
Rose Chafer 69, 74, 178
Rose Beetle 69, 74, 178
Rose Bug 69, 74, 178
Rot of Potatoes defined 1
Rusted Wheat 228
Rusted Wheat Straw, composition of 229
Rye, Glutenous and starchy 224

S

San Jose Scale 57
Saw-toothed Grain Beetle 45
Scab of Potatoes 7
Scale, Cottony Maple 181
Scale, Lecanium on Scotch Pine 183
Sciapteron polistiformis 65
Screech Owl 141
Seedling potatoes 9
Sesia tipuliformis 56
Silvanus surinamensis 46
Sitotroga cerealella 42
Slender-horned Four Beetle 44
Slugs 179, 180
Slugs on Lettuce 175
Snail, Naked 180
Snowy Tree Cricket 49, 66
Soft Maple, Gallmakers on 185
Soil investigation 192
Soils, Plant Food of 198
Soils, Humus in 200
Some of our Common Birds 128
Spelosoma virginica 62
Spermophilus richardsonii 152
S. franklinii 151
S. tridecemlineatus 150
Spittle Insect 67
Spotted Paria 77

Spotted Pelidnota 72
Spraying and Spraying Machinery 92
Spraying Machinery, List of Manufacturers 97
Squash Insects 80
Squash Bug, True 80
Stalk Borer 51, 78, 175, 177
Station Officers II
Strawberry Insects 47
Strawberry Weevil 52, 78
Strawberry Root Borer 74
Strawberry Crown Borer 75
Striped Cucumber Beetle 81
Striped Flea Beetle 78
Synchlora glaucaria 55

T

Tarnished Plant Bug 78
Tenebrio molitor 45
Tenebroides mauritanicus 37, 46
Thymaris slingerlandana 73
Toad, The Common, a Friend to Gardeners 166
Tmetocera ocellana 52
Trapezonotus nebulosus 16
Tribolium confusum 36, 44
Turkeys 258
Tyloderma fragariae 75
Typhlocyba, sp 70

V

Varieties of potatoes 3
Vesper Sparrow 134
Vesper Bird 134
Veterinary Division X

W

Weevil, Strawberry 52
Wheat 219
Wheat, Glutinous and Starchy 219
Wheat, Milling Tests of 232
Wheat, Rusted 228
Wheat Stem Maggot 15
Wheat straw, rusted, composition of 229
Wire Worms 76, 172
Woodchuck 162

Y

Yellowhammer 137
Yellow Bear, Common 62
Yellow Meal Worm 45

Z

Zophodia grossulariae 62